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DUPLEX TELEGRAPHY.

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(Continued from page 279).

I will now explain the irregularities in working to which circuits are liable when duplexed, their causes, and the means adopted, by the different methods introduced, to remedy or reduce their effects. They are due (1), to variations in resistance; (2), to electrostatic induction; and (3), to electro-magnetic induction.

1. *Resistance.*

The *resistance* of a body is the obstruction which it offers to the transference of electricity through it. The reverse quality, viz., the facility which it offers to this transference, is termed its *conductivity*. These are reciprocal terms, and being practically synonymous, the latter word has almost disappeared from the vocabulary of the telegraph engineer. The obstruction and facility to the passage of the current through a circuit are similarly implied by the term resistance. A mass of great resistance obstructs, and a mass of small resistance facilitates the flow of electricity. Reciprocally the latter is said to conduct well, and the former to conduct badly; and if the bad conductor conduct very badly, it is said to *insulate*. Hence *insulators* are masses which oppose great resistance, *conductors* are masses which oppose small resistance to the flow of electricity through them. In this way insulation and conduction are both implied in the single term, resistance.

Now all telegraphs between any two points connected together consist of conductors supported by insulators stretched or laid either in the air, beneath the ground, or under the sea. In the air we have iron wires, which offer little resistance, supported at intervals by earthenware, porcelain, or glass knobs, which offer very great resistance. Beneath the ground and under the sea we have copper wires, which offer even less resistance than the iron, entirely enveloped by several layers of gutta-percha, india-rubber, or other compounds which offer the greatest possible known resistance to the passage of the current.

In the first case, the practical insulator, or the material which resists the escape of the current, is not so much the earthenware or glass itself which forms the support, as the water or moisture which is deposited upon its surface. Hence, aërial insulation is reduced to a question of form, and immense ingenuity has been expended in devising the best form of surface to give the greatest amount of resistance in the worst kind of weather. In the second case, the insulator is the mass of the substance itself, and its efficiency depends entirely upon the nature of the material, upon its thickness, and upon the skill with which the different layers have been laid and the different joints made. In the air insulation is a question of exposed surfaces; underground and submarine it is a question of enclosed masses.

Let us, in the first place, assume our two stations, A and B, connected together by an aërial telegraph consisting of an iron wire supported at every 100 yards upon an earthenware insulator fixed to an arm upon a pole. The air itself is practically an absolute insulator; dry air is the most perfect insulator known. If the wire could be stretched from A to B without any support at all, all the current which left A would reach B without any diminution or loss; but, inasmuch as it must be supported at intervals of about 100 yards by masses which are not absolute insulators, but which allow a small portion of the current to pass through or over them, the current which arrives at B must necessarily be less than that which leaves A.

Precisely in the same way, if we had a pipe conveying water punctured with a small hole at every 100 yards, through each of which a thin stream leaked, the amount of water which arrived at the distant end would be less than that entering the near end by the amount which escaped. On the other hand, if the pressure at the near end be maintained constant, the absolute amount of water which enters the pipe at that end is greater when the pipe is leaky than when it is whole.

Thus we see that, since every insulator is a leakage or an additional outlet for the current, more electricity will leave A when these supports are used than would be the case if the wire were stretched supportless. Hence they have the same effect upon the current leaving A as the reduction of the resistance of the wire. In fact, these leakages do reduce the resistance of the circuit. I have already pointed out that the strength of the current is merely a function of its resistance when the difference of potential remains constant. If the strength increases with the same electro-motive force, it is due to a diminution of resistance; if the strength diminishes under the same conditions, it is due to an increase of resistance. Hence, any variation in the resistance of the circuit affects the currents leaving A, and this variation is produced either by an alteration of the physical condition of the mass of the conducting wire, or by a change in the character of the mass or surface of the insulating material. It follows, therefore, that the strength of the currents which flow from A to B are dependent, first, upon the resistance of the aërial wire, and, secondly, upon the resistance of the insulators that support that wire.

Now, the resistance of the wire itself is only affected by the changes which occur in its temperature. Resistance is unquestionably a property of the molecules of matter. Any variation in the condition of these molecules disturbs their capacity for the transference of electricity. Heat has this influence. As the temperature of a metal increases or diminishes, so does its resistance. Iron wire increases in resistance 0·21 per cent for each degree (Fahr.) through which it is raised. The diurnal variations of temperature in this climate are not great; in summer the greatest range is about 30°. This would not practically affect the comparatively short circuits we use, but in India and America, where the circuits are much longer and the daily variation much greater, considerable difference must be experienced in the resistance of the wire as between midday and midnight.

But the resistance of the insulating supports varies incessantly. The resistance which the mass of an insulator offers to the current is practically constant, but its surface is incessantly undergoing change by the deposition of moisture and dirt upon it. I have mentioned that it is the moisture and dirt which are practically the insulator, and hence insulators owe their efficiency more to the form of their surface than to the quality of their substance. The resistance of an insulator is therefore practically the resistance of the layer of water condensed or deposited on its surface. Hence, every shower of rain, fog, dew, and mist affect its resistance. Lines exposed to the spray of the sea or to the smoke of manufactures are peculiarly liable to variations.

Thus it happens that the resistance of an aërial telegraph is constantly varying, and therefore the currents which flow through it are constantly subject to change. The longer the line the greater must be the extent of this variation. The amount of variation depends essentially upon the character of the country through which the line passes and the nature of the weather. The resistance of some lines varies as much as 50 per cent in one day in bad weather, while in fine weather it remains practically constant. Short lines, as a rule, are little disturbed by variations of short duration, but long lines of 200 miles and upwards are the subject of constant variations due to atmospheric changes at different points. A thunderstorm here, a shower there, excessive radiation at one point, cloudiness at another point—all tell their tale.

In England we are peculiarly liable to great variations in the resistance of our lines, not only from the excessive moisture of our climate, but owing to the special means which we have taken to prevent the escape of currents from one wire to another on the same pole, which occurs either with indifferent insulators or with broken and defective ones. This is due to "earth wiring," or the erection of iron wires on every pole, to allow the leakage at once to pass to earth without interfering with any other wire.

As an illustration of the changes of resistance in a line 280 miles long, I give the records of two days—the one a wet day, and the other a fine day:—

Weather at Recording Station.	Time.	Resistance in ohms.
	A. M.	
Wind S.E. 13th September—		
Showery	12.30	2476
Rain	10.25	2272
,, ...	11.10	2086
Heavy Rain ..	11.15	1611
,, ,, ..	11.50	2272
	P. M.	
Rain	2.55	2476
,, ...	3.25	2700
,, ...	4.15	2476
,, ...	4.17	2272
Clearing up ..	4.50	2476
,, ,, ..	5. 5	2272
,, ,, ..	5.20	2086
Fine	5.25	1917
,, ...	5.28	2947
,, ...	9.40	2423
Fog	9.45	2133
,, ...	10. 0	2476
Wind N.W., 18th September—		
	A. M.	
Fine	9.40	3714
	P. M.	
,, ...	5. 0	3407
,, ...	7.15	2874

It will be seen how rapid and sudden were the changes in the former case, and how constant those in the latter. The sudden depression at 11.15 a.m. on the 13th was probably due to some severe weather occurring on some portion of the line. The fall on the evening of the 18th was probably due to the formation of dew. As an interesting record of the daily variations of a line in England, I give the resistance in ohms at midday and midnight for every day for a month:—

Date.	Midday.	Midnight.
Sept. 1	3222	3128
,, 2	3714	2640
,, 3	3714	3714
,, 4	4421	4421
,, 5	4050	3350
,, 6	4421	3407
,, 7	4050	4050
,, 8	4000	3128
,, 9	2272	3128
,, 10	3714	1611
,, 11	4050	3714
,, 12	3714	2874
,, 13	2272	2476
,, 14	3407	2476
,, 15	3128	3714
,, 16	3714	2272
,, 17	1916	2947
,, 18	3714	2874
,, 19	1916	1350
,, 20	2272	2947
,, 21	2947	2947
,, 22	3714	3714
,, 23	3714	3128
,, 24	4050	4050
,, 25	4050	2874
,, 26	3407	3407
,, 27	3714	2272
,, 28	4000	3572
,, 29	3891	2378
,, 30	3407	2640

But there are other causes besides wet weather which interfere with the constancy of the resistance of an aërial wire. It may be brought into contact with other wires upon the same poles by the position of the pole itself being disturbed, by falling branches, trees, or rocks, by high loads at crossings, by whip lashes, by kite strings and cotton waste, by careless workmen, and even by the wind itself when very high. Loose or broken stays may place the wire in contact with signal posts, walls, bridges, and trees. Trees, unless carefully lopped, may grow up amongst the wires. Joints may become bad from the absence or failure of the solder. Malicious or thoughtless persons may twist them together. Various moving accidents by flood and field disturb the wires, and these disturbances are evidenced by varied resistance. But subterranean and submarine wires are free from all these vicissitudes. The resistance of their insulating coating is practically constant. Cables lie beneath the sea upon a cushion of equable temperature, and they are far removed from atmospheric disturbances.

But the potentials at the extremities, as well as the resistance of the line, may vary. The variation of the difference of potential has the same effect upon the currents as the variation of resistance. The potential of the earth varies at different times and in different places from some unknown cosmical cause. By this variation of the difference of potential at the extremities of a line, currents are produced in our wires called *earth currents*, which vary both in direction and strength sometimes rapidly, sometimes slowly. Lines running easterly and westerly are much affected by them, but not so much those running north and south. They are always more or less present, and vary diurnally with much regularity, apparently following the motion of the earth about its axis. These daily currents do not much disturb the working of our circuits, though they tend to diminish the speed of working of those long circuits which are exposed to their influence. For instance, between London and Dublin the rate of working invariably diminishes towards noon, when these currents are at their maximum.

It is, however, their occasional and exceptional variation which disturbs the working of circuits. All great terrestrial and atmospheric changes are accompanied by electrical disturbances especially those which culminate in auroræ thunderstorms and earthquakes. Auroræ especially are generally preceded by currents of great strength, overcoming entirely the working currents, and breaking down the ordinary telegraphs. These currents are sometimes steady, but they more generally vary rapidly in strength and duration. Thunderstorms are also accompanied with current effects which disturb the working of the wires, and there are many authentic cases of such currents preceding earthquakes.

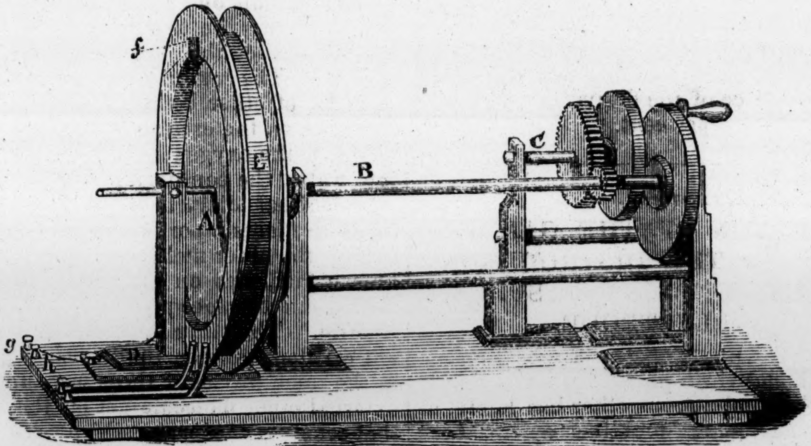
In fact, telegraph wires are in a constant state of change, and it was this variation in their condition which rendered the earlier experiments in duplex telegraphy a failure.

(To be continued).

THE ELECTRIC RESISTANCE OF MERCURY IN ABSOLUTE MEASURE.[*]

By M. LORENZ.

THE various determinations of the electric resistance of mercury in absolute measure by Weber, the Committee of the British Association, and Kohlrausch, notwithstanding much care in experiment, are somewhat discordant. The methods all agreed in the use of induced *currents* of *variable* strength. As this appeared to me to be the source of discrepancy, I have sought for some other way in which a *constant* electromotive force, *without* current, might be employed.



The annexed figure shows the apparatns I have used. A brass disc, A, is fixed at the end of an easily-turned axis, B, connected by wheel-work at the other end with another axis (each axis having a driving-wheel. The disc, A, turns within a mahogany ring very little larger, and fixed to a stand, D, movable in the direction of the axis. The ring is wound round with several regular coils of silk-covered copper wire 1 m.m. thick. The upper part of the stand carries a brass rod, the point of which can be pressed against the centre of the disc, and thus the disc be electrically connected with the binding-screw, g. Another binding-screw, near this, is connected with a thin brass slip, which, fixed to the wooden ring, presses against the disc. Two other binding-screws, h, are connected with the wire passing round the ring.

If, now, an electric current is sent through the ring wire, and the disc put in rotation, there arises, through induction, a difference of tension between the centre and the periphery of the disc, and if the screws g be connected with a multiplier, a deflection will be observed. The principal current is now passed through a conductor whose resistance is to be measured, *e.g.*, through a column of mercury in a cylindrical glass tube, two platinum wires being soldered into the walls of the tube. This derived current is introduced into the circuit of the induced current in such a way that both currents pass by the same path to the multiplier. The disc is now rotated in such a direction that the two currents are contrary to each other; and with a certain velocity of rotation, they will exactly *neutralise* one another, so that the needle comes to zero. This velocity of rotation, multiplied by a constant calculated for the apparatus, will give the absolute resistance of the mercury column between the platinum wires. Let w be this resistance, and s the strength of the principal current, then the electric difference of tension in the platinum wires is $s\,w$. Further, let P denote the difference of tension between centre and periphery of the disc, when the intensity of the principal current is unity, and the disc is turned with uniform velocity in the second. Then, if the intensity of the principal current is s, and the disc rotates n times in the second, the electromotive force, from induction, is $P s n$. Now, $s w = P s n$, and hence $w = P n$, if the multiplier shows no current. The resistance is, therefore, independent of the intensity of the principal current, and the measurement is limited, if once the constant, P, of the apparatus is known, to determining the number of rotations of the disc in a second for each resistance to be measured.

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[*] Abstract of paper in "Poggendorff's Annalen."

I had thought to ascertain the velocity of rotation by electric apparatus, but unexpectedly obtained great accuracy through simply turning with the hand, and counting the revolutions, while the time was given by the minute beats of a clock. One double chromic acid potash element was a sufficient electromoter. [Various precautions taken for avoidance of errors, are detailed. The author also shows how he estimated the constant of the apparatus].

From a series of experiments with different-sized tubes, different quantities of mercury, &c., it is found that on the average 1 mercury unit=0·9337 Ohm's unit. Or, the mercury unit is equal to $0{\cdot}9337{\cdot}10^{10}$ absolute units.

This result, in which the error could hardly exceed 0·2 per cent, is about 2 per cent under that obtained by the British Committee (0·9629 and 0·9564 Ohm's unit), which, again, is lower than that by other observers (Kirchhoff, perhaps, excepted,) as Weber gives the value 1·0257 Ohm's unit, and Kohlrausch, 0·9705.

I will here mention some other experiments I made with my apparatus. If the principal current is interrupted while the disc is turned, and the needle stands at zero, the needle receives an impulse, and is deflected several degrees. The direction of this proves that the derived current, at the moment of interruption, prevails over the current induced in the disc.

Experiments were also made with an intermittent principal current. They gave, for the measured resistance, a result about 1 per cent too high, but I ascribe this difference to error of observation, because in these experiments it was more difficult to keep the needle at perfect rest, and, with a restless state of the needle, one is inclined (according to my experience) to turn the disc too quickly.

I made some experiments to find whether the length of the mercury column above the upper platinum wire had any influence on the result. This length, in the experiments described, was about as great as the distance between the two platinum wires. Mercury being removed from above, no difference in the result was met with till the mercury surface was about 1 m.m. above the upper platinum wire. In this case, the resistance observed was about 1 per cent too small; that is, the electromotive force of the derived current was now diminished about 1 per cent.

ON THE

CHEMICAL ACTION OF THE GALVANIC CURRENT, AND THE DISTRIBUTION OF FREE ELECTRICITY ON THE SURFACE OF AN ELECTRODE.

THE theory that electrical phenomena are simply phenomena of the luminiferous ether has lately, as many of our readers are doubtless aware, been enunciated by a Swedish physicist, Professor Edlund. About two years ago he communicated to the Stockholm Academy a paper in which the theory was partly developed; an explanation being given of electrostatic attractions and repulsions, electrodynamic phenomena, galvanic induction phenomena, and rotation of the plane of polarisation through the action of a current. The subject heading this note was also touched upon, though briefly; but has been more fully discussed in a later communication to the Academy, which appears in a recent number of *Poggendorff's Annalen*. The first point considered is the chemical action of a galvanic current, and the following may be taken as a brief account of the author's explanation of this phenomenon.

Whatever idea may be formed of the nature of electricity, we must suppose, in order to explain the decomposing power of the current, that electricity has an unequal action on the matters separated from each other. It must either attract one substance and repel the other, or attract or repel both, but with unequal force. Now we know, from the physical doctrine of light, that material bodies have the power of attracting ether molecules, and of condensing ether in their interior, until the attraction by the matter for an external ether molecule is just as strong as the repellent force of the condensed ether on the same molecule. A material body, with its condensed ether, has thus, on the whole, no influence on the external free ether; and this is the case whether the free ether is in motion or at rest. Again, it is known, that different kinds of matter have unequal attraction for ether molecules. Some attract them more strongly than others. The quantity of ether held condensed by the oxygen molecules in a mass of oxygen is not equal to the quantity held condensed in a hydrogen mass, &c. We may take water for one example of an electrolytic fluid; and if we denote the quantities of ether condensed by the two constituents, by e_o and e_h respectively, then e_o and e_h are unequal. The attraction of an external ether molecule to the oxygen molecule is just as strong as its repulsion by the condensed quantity e_o; and similarly, the attraction of the external ether molecule to the hydrogen molecule is just as strong as its repulsion by e_h.

Now when the oxygen and hydrogen molecules unite to form water, we must suppose that the water molecule formed contains a quantity of ether $e_o + e_h$ in condensed state. The attraction of the water molecule on an outside molecule is again just the same as the repulsion between this ether molecule and the condensed quantity of ether $e_o + e_h$. The water molecule, together with the quantity of ether condensed by it, is thus without influence on the external free ether.

When the oxygen and hydrogen molecules unite into water, the equilibrium of the condensed ether is somewhat disturbed, so that one of the two molecules loses a portion of its supply, which gives over to the other molecule. This agrees with the known fact, that on contact of two heterogeneous bodies, one becomes positively, the other negatively electric. The ether in the water molecule is thus not divided between the two chemical constituents in the same way as if these were free. If, now, an external ether molecule act on the water molecule, that constituent of water which contains a somewhat smaller quantity of ether than in the free state will be attracted, and the other repelled. The first constituent will thus tend towards the external molecule, and the mass of ether contained in the water molecule will be driven more and more, by the repellent force, to the retreating constituent of the water. Thus the force which seeks to separate the hydrogen from the oxygen ever grows, till at last the chemical combination ceases to exist. It is clear that, on this conception of the phenomenon, the repulsion of the one constituent of water, or rather the mass of ether which this constituent contains in excess, is equally great, with the attraction for the other constituent.

The author develops these principles mathematically, and shows how they apply to several facts of electrolysis.

Experiment has shown, that the weakest current passing through a liquid decomposes it. We must accordingly suppose that the weakest current is capable of transferring the ether from the oxygen molecules to the hydrogen, or conversely. In proportion as the ether molecules are thus transferred, the power of the current to separate hydrogen from oxygen grows till the chemical combination is dissolved. All depends on the ease with which the ether molecules are transferred from one constituent to the other.

That the equilibrium of ether in the water molecules is not unstable may be thus explained: when the water molecule, as is generally the case, is in a mass of ether at rest, it is clear that the position of equilibrium of the ether condensed by the oxygen and the hydrogen depends, in great part, on the free ether with which it is surrounded. The pressure of the free ether on the condensed is nearly equal on all sides. If now the pressure of free ether be in any way altered on one side, the condensed ether molecules will necessarily change their position of equilibrium. But this is exactly what occurs when the water molecules come into the galvanic current. It is not conceivable that the condensed ether remains undisturbed in its position, when the free ether about it begins to move. One constant hindrance to the motion of the ether molecules from one constituent of water to the other is, however, the galvanic resistance of the conductor. But this is proportional to the strength of the current, that is, proportional to the velocity with which the movement takes place. Thus the resistance does not render it impossible for the weakest current to transfer the ether from one position to the other.

We now come to the author's explanation of the distribution of free electricity (or free ether) on the surface of a galvanic electrode.

Suppose a tube, the gaseous mass in which is put in motion by a force operating at one end, the gas streaming freely out of the other end. We understand that the resistance of the tube to the motion of the gas is proportional to its length. Calling the distance from the open end to a given cross section, x, the resistance in this section is proportional to x. Let D' denote the density of gas in that section, and D the density at the open end of the tube; then, as soon as the motion has become constant, the difference $D' - D$ is proportional to the distance x. The density of the gas increases from the open end to the end where the force acts.

Conceive, now, that the two ends of the tube are united, so that the moving gaseous mass is quite enclosed. The gas must then be just as much rarefied in one portion of the tube as it is condensed in the other, and at the transition surface between the two parts the gas has the same density as if it were at rest. If the tube is of the same thickness and nature throughout, this transition surface divides it into two parts of equal length. At equal distances from this surface the condensation on the one side is just as great as the rarefaction on the other. If the resistance in one part of the tube is greater than in the other, then the transition surface is shifted so far towards the part which has greatest resistance that the resistance in the whole of this portion (reckoned from the transition surface to the place where the force acts) is just as great as the resistance in the whole of the other portion. If D and D' denote the density of the gas at the transition surface, and at any other surface on the side on which the gas is condensed, then $D' - D = a\,m$, where a is a constant, and m is the resistance from the transition surface to the surface just referred to. If D'' is the density of the gas at any other surface, on the other side of the transition surface, then similarly $D - D'' = a\,m''$, where m'' denotes the resistance between the surfaces specified.

These principles find immediate application to the current ether. It has the property, like an ordinary gas, of communicating pressure in all directions, because its molecules are readily movable. The circumstance that an electrical body has the same optical properties as in the normal state, indicates that the elasticity of the free ether is proportional to its density. Accordingly, what has been said about an ordinary gas will hold good for the ether. The only difference is that the condensation and rarefaction of the ether can only take place at the surface of the galvanic conductor, and not in the interior, because the ether molecules repel each other.

In a closed galvanic circuit the ether is, on one side, put in motion by the electromotive force. It must therefore be condensed on that side of the electromotive force, whither the current goes, and consequently rarefied on the other side. The transition surface is in such a position that the galvanic resistance of the conductor from this surface to the point where the force is working is just as great on the one side as on the other. Call the strength of current s, the density of ether at the transition surface, or (the same thing) the density of ether at rest, D, its density at any two surfaces on the condensation side D' D'', and on the rarefaction side D_o' D_o''; further, the resistance for the unit of current strength between the transition surfaces and the surfaces named, m' m'' m_o' m_o''; we have (since the resistance is proportional to the strength of current), $D' - D = m's$; $D'' - D = m''s$; $-(D_o' - D) = m_o's$; $-(D_o'' - D) = m_o''s$. But $D' - D$, $D'' - D$, $D_o' - D$, $D_o'' - D$, are no other than the electroscopic tensions of the respective surfaces, the two first positive, the two last negative. If we call the former T' and T'', and the latter T_o' and T_o'', we have—

$$T' - T'' = (m' - m'')\,s \text{ and } T_o' - T_o'' = (m_o' - m_o')\,s$$
$$T - T_o' = (m' + m_o')\,s \text{ and } T'' - T_o'' = (m'' + m_o'')\,s.$$

That is, the difference between the electroscopic tensions for any two points on the surface of the conductor is proportional to the product of the strength of current and the resistance for the unit of current strength between these points.

Calling m the resistance of the whole circuit for the current strength 1, and T the tension in the immediate neighbourhood of the electromotive force; then, as the resistances between the transition surface and the point where the force acts are equal on both sides, we have—

$$s = \frac{2T}{m} = \frac{E}{m}$$

which, it is known, agrees with experiment.

On closer consideration (Prof. Edlund concludes) one finds that the experiments made to determine the distribution of electricity on the surface of a galvanic conductor, leave it quite uncertain whether this is in motion or at rest. It is merely affirmed that the ether on the surface of the conductor has a greater or less density than in the normal state, and consequently shows a certain tension. We, therefore, do not for the present enquire whether the ether which produces electroscopic tension is at rest or in motion.

KOHLRAUSCH ON ELECTRICAL MEASUREMENTS.

Much has been written upon Electrical Measurement, yet within a certain limit much of what has been written is confined to the method of the measurement, and not to its accuracy. The advent of a work*—the translation from the German of Prof. Kohlrausch's "Physical Measurements,"—devoted entirely to accuracy, or perhaps it should be said to the elimination of error, is a matter of more than passing interest to the electrician. Those electrical laws that make themselves manifest on the crudest of instruments have been read and recorded; investigators in the future will derive most profit who employ the most accurate method. Prof. Kohlrausch has so long been known as an authority in experimental method—measurements recorded in his laboratory have always stood the test of so lengthened verification—as to have drawn students to his chair from all parts of the world. The issue of a work from his pen, and the translation of this work into English, is an event of so high importance that too great stress can scarcely be brought to bear. We propose, then, to place before our readers a selection from Dr. Kohlrausch's work—his simple remarks on the measurement of currents with the tangent galvanometer. For the calculation of the errors of observation, the mean and probable error, the determination of empirical constants by the method of east squares, &c., we must refer to the work itself; it would be impossible to condense, and to extract would be useless.

The case first treated of is that of relative measurement by the tangent compass, in which we are told the "angles of deflection should be neither very large nor very small, those of about 45° being most advantageous. It is necessary, therefore, for currents of very different intensities to employ galvanometers of different degrees of sensitiveness; that is, with coils of different diameters or of different lengths, or the instrument may be so constructed that the current may be passed through a greater or less number of coils as required. The results of different instruments may be compared with each other by passing the same current through both at once. If, for instance, we obtain in this manner a deflection of 66·5° in the first instrument, and of 14·2° in the second, the tangents of the deflection of No. 1 must be multiplied by—

$$\frac{\tan 14{\cdot}2^\circ}{\tan 66{\cdot}5^\circ} = \frac{0{\cdot}253}{2{\cdot}30} = 0{\cdot}110,$$

to make them comparable with those of No. 2.

"The tangent-compass is usually adjusted so that the needle points to zero when the plane of the coils is in the magnetic meridian. Whether this is accurately the case must be tested, preferably by the employment of a very short needle, for the proportionality of current-strengths to the tangents of the angles of deflection only holds good if the instrument be exactly placed, and especially so with powerful currents. This difficulty may, however, be easily avoided by passing the current successively in opposite directions through the galvanometer, and taking the mean of the deflection to both sides (half the combined deflection) as ϕ. In the value thus obtained, errors from incorrect position are eliminated. It is convenient for this purpose that a commutator should be permanently connected with the galvanometer, which will allow the current to be reversed without altering any other part of the circuit. This gives the additional advantage of a double degree of accuracy, and renders it unnecessary to observe the zero-point exactly; and, lastly, a well-arranged commutator serves conveniently to open and close the circuit."

The deviation from the law of proportionality of tangents is then considered, with the best means of bringing the needle to rest. Valuable as the matter would be, we cannot here enter into the measurement of currents in absolute magnetic units with the tangent-compass, &c. There is one more quotation that will recommend itself to the reader, and it relates to measurement with reflecting instruments, to the reduction of observations with the scale to angular measure.

"We will reckon all angles of rotation from the *mean position** as zero, and denote by ϕ the angle of deflection through which the magnet, &c., is turned from this position. As scale-deflection, we take the difference, n, of the observed from the middle scale division.

(1). For small deflections the angle is proportional to the scale-reading; and, indeed, if r be the distance of the reflecting surface from the scale, expressed in scale-divisions (millimetres, if it be a millimetre scale), the value of 1 division in degrees of arc is—

$$= \frac{28{\cdot}648^\circ}{r} = \frac{1718{\cdot}9'}{r} = \frac{103132''}{r}.$$

The error may amount at most in deflections of—

1° 2° 3° 4° 5°

in parts of the whole to—

0·0004 0·0016 0·0036 0·0064 0·010.

(2). For a deflection not exceeding 6°, we may always with sufficient accuracy take—

$$\phi = \frac{1718{\cdot}9'}{r}\, n \left(1 - \tfrac{1}{3}\frac{n^2}{r^3}\right)$$

Frequently a trigonometrical function is required instead of the angle itself—

$$\tan\phi = \frac{n}{2r}\left[1 - \left(\frac{n}{2r}\right)^2\right]$$

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* An "Introduction to Physical Measurements, with Appendices on Absolute Electrical Measurement, &c." By Dr. F. Kolrausch, Professor-in-ordinary at the Grand Dufcal Polytechnic School at Darmstadt, and formerly Prof. of Physics at Gottingen. Translated from the Second German Edition, by Thomas Hutchinson Waller, B.A., B.Sc.; and Henry Richardson Procter, F.C.S. London: J. and A. Churchill, 1873.

* The *mean position* is the corresponding position of the magnet to the middle scale division.

$$\sin\phi = \frac{n}{2r}\left[1 - \tfrac{3}{2}\left(\frac{n}{2r}\right)^2\right]$$

$$\sin\frac{\phi}{2} = \frac{n}{4r}\left[1 - \frac{11}{2}\left(\frac{n}{4r}\right)^2\right]$$

Hence we reduce a scale reading n to the corresponding arc, tangent, sine, and sine of half angle by subtracting $\frac{1}{3}$, $\frac{1}{4}$, $\frac{3}{8}$, or $\frac{11}{33}\frac{n^3}{r^2}$ respectively from n.

(3). For considerable deflections—

$$\phi = \tfrac{1}{2}\tan^{1-}\frac{n}{r}$$

The last formula is given by simple geometrical considerations, the others by taking the first two terms only of the series for the development of ϕ, $\tan\phi$, &c.

To congratulate the translators, who have added several useful tables and appendices, is needless; the book will be invaluable to every physicist.

MATHEMATICS
FOR
NON-MATHEMATICIANS.

By W. PAGET HIGGS, LL.D., D.Sc.

Division I.—The Algebra of Constant Quantities.

(Continued from p. 300.)

Division, Fractions, and Ratio (*continued*).

We may now turn our attention to fractions. Fractions appear to be to many the most difficult section of elementary mathematics; and treated in the abstract there is no doubt there must be attained a high mental culture before their meaning and powers can be fully understood. Indeed, it would seem impossible to impart to one entirely ignorant of mathematics a knowledge of fractions from merely their abstract consideration. In dealing with this section of our papers it will, therefore, be forgiven us if we incline to more concrete detail than the reader may think necessary.

What is a fraction? A fraction, says Mr. Merrifield, in his admirable text-book of arithmetic,*—a fraction of anything is a given portion of it. If we divide anything, no matter how, any piece of it is a fraction of it. The simplest fraction is *one-half*, and is expressed as follows: $\frac{1}{2}$. If we divide a thing, say a cake, into three equal pieces, and take one of them, we call that piece *one-third* of the cake, and we express it as a fraction thus—$\frac{1}{3}$; and so, if we divide it into four, and take one portion, we call it a quarter, or one-fourth, and write it $\frac{1}{4}$. So, also, if we divide a cake into x pieces, we should call each piece $\frac{1}{x}$; if into a pieces each would be $\frac{1}{a}$. It is evident that the whole cake may be considered as two halves (which we write $\frac{2}{2}$), three thirds ($\frac{3}{3}$), four quarters ($\frac{4}{4}$), and the same with any other number. Again, since we cannot divide a cake into less than two pieces, it is clear that division by the number *one* leaves it just as it was, one whole cake, which we may therefore write $\frac{1}{1}$, and this is all we mean by writing—

$$1 = \tfrac{1}{1} = \tfrac{2}{2} = \tfrac{3}{3} = \tfrac{4}{4} = \tfrac{1001}{1001}, \text{ \&c.}$$

If we divide the cake into a good many parts (say 12), and take any number of these parts (say 7), we express the whole portion taken thus: $\frac{7}{12}$. The number below the line is called the denominator, and expresses the number of parts into which we divide the thing; the number above the line is called the numerator, and expresses the number of parts taken:—

$$\text{Fraction} = \frac{\text{numerator}}{\text{denominator.}}$$

Premising that our arithmetical knowledge extends thus far, we may take those rules given for the working of fractions, and endeavour to see in what manner they apply. The rules are concisely stated, as—

Rules for Fractions.

Addition and Subtraction.—If the fractions have a common denominator, add or subtract the numerators, and place the sum or difference as a new numerator over the common denominator.

If the fractions have not a common denominator, they must be reduced to that state before the operation is performed.

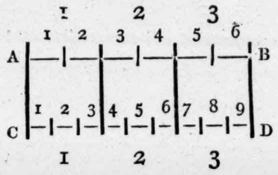
Multiplication and Division.—To multiply a fraction by an integral quantity, multiply the numerator by that quantity, and retain the denominator.

To divide a fraction by an integral quantity, multiply the denominator by that number, and retain the numerator.

To multiply two or more fractions is the same as to take a fraction of a fraction; and is, therefore; effected by taking the product of the numerators for a new numerator, and of the denominators for a new denominator. (The product is evidently smaller than either factor when each is less than unity).

To divide one fraction by another, invert the divisor, and proceed as in multiplication. (The quotient is always greater than the dividend when the divisor is less than unity.)

Now we find in the first words of our first rule the phrase "common denominator." We may, to the better understanding of this phrase, take an arithmetical example. Let us divide two lines into a number of equal parts—the line A B into 6 parts, and the line C D into 9 parts:—



Now the line A B will represent a denominator of 6, and the line C D a denominator of 9. For a numerator (the number of parts we take) let us write down 2. We see that two-sixths, three-ninths, and one-third are the same. So that were we asked to add together three-ninths and one-third, we should reply that the answer was two-thirds. Unconsciously we have performed the operation known as "*reducing the fractions* ($\frac{3}{9}$ and $\frac{1}{3}$) *to a common denominator*"—that is, we have found the value of three-ninths in thirds. While the *denominations* of the quantities were different we could not add them, but directly the value of one in terms of the other was known addition could be proceeded with.

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* "Technical Arithmetic and Mensuration." By Charles W. Merrifield, F.R.S., Principal of the Royal School of Naval Architecture and Marine Engineering, &c. Longman's "Text-Books of Science." 1872.

To reduce fractions to a common name or denominator the following rule is generally given:—

Multiply *each* numerator by the *product* of all the denominators *except its own;* the results will be the numerators of the new fractions.

The *product* of *all* the denominators will be the new denominator common to all the new fractions.

To apply our rule, let it be required to add—

$$\frac{a}{b}+\frac{c}{d}+\frac{e}{f}.$$

We have—

$$\frac{adf}{bdf}+\frac{bcf}{bdf}+\frac{bde}{bdf}=\frac{adf+bcf+bde}{bdf}$$

as the sum. The fractions—

$$\frac{a}{b}+\frac{c}{d}+\frac{e}{f}$$

have not been altered; they have, by the multiplication in each case of numerator and denominator by an equal quantity (see p. 300), taken a new form. The equal quantities are for a over b, df; for c and d, bf; and for e and f, bd. And these equal quantities have been determined by the fact that bdf is a product that contains all these factors—in other words, by the fact that bdf is a common multiple of b and d and f. The reduction of fractions to a common denominator is then resolved into finding a common multiple of the denominators of all the fractions, and multiplying the numerator of each fraction by the factors foreign to itself.

It may be remarked that if a common multiple have a common measure or common divisor, the result of the division of the multiple by the *greatest common divisor* or *measure* is termed the *least common multiple.* These phrases are sometimes expressed by the initial letters G. C. M. (greatest common measure) and L. C. M. (least common multiple). A common multiple of 6 and 4 is 24; but the numbers 6 and 4 have a divisor, 2, common to both, and the *least* common multiple of 6 and 4 is therefore 12.

The following formulæ will serve to illustrate the principles of the preceding sections, and to render the reader familiar with the expression of principles in symbols:—

$$\frac{a}{b}=\frac{ma}{mb} \qquad \frac{a}{b}=\frac{1}{b}\times a.$$

$$\frac{a}{b} \text{ and } \frac{c}{d}=\frac{ad}{bd} \text{ and } \frac{bc}{bd}.$$

$$\frac{a}{b}+\frac{c}{d}=\frac{ad+bc}{bd}.$$

$$\frac{a}{b}-\frac{c}{d}=\frac{ad-bc}{bd}.$$

$$\frac{a}{c}\mp\frac{b}{c}=\frac{a\mp b}{c}.$$

$a \mp b$ should be read, a minus *or* plus b, addition or subtraction being performed as dictated by the application of the formula.

$$\frac{a}{b}\times\frac{c}{d}=\frac{ac}{bd}.$$

$$\frac{a}{b} \text{ divided by } \frac{c}{d}=\frac{a}{b}\times\frac{d}{c}=\frac{ad}{bc}; \text{ or—}$$

$$\frac{\;\frac{a}{b}\;}{\frac{c}{d}}=\frac{ad}{bc}.$$

And the following examples given by Prof. De Morgan will prove useful:—

$$\frac{1}{a+\frac{1}{b}}=\frac{b}{ab+1}.$$

$$\frac{1}{a+\cfrac{1}{b+\frac{1}{c}}}=\frac{1}{a+\frac{c}{bc+1}}=\frac{bc+1}{abc+a+c}.$$

Thus—

$$\frac{1}{6+\cfrac{1}{7+\frac{1}{8}}}=\frac{1}{6+\frac{8}{57}}=\frac{57}{350}.$$

PRACTICAL ELECTRO-PLATING.

Coating with Nickel.

Napier, in his "Manual of Electro-Metallurgy," speaks of nickel coating; that it is very easily deposited and may be prepared for this purpose by dissolving it in nitric acid, then adding cyanide of potassium to precipitate the metal, after which the precipitate is washed and dissolved by the addition of more cyanide of potassium. The cyanide of potash has proved unsuitable for nickel plating; he says that he coated articles with nickel in 1847, and up to 1853 they still retained their brilliancy and continued untarnished. Napier gives also the following practical instruction for plating, in the following words:—It is indispensable that the battery should be so arranged that the quantity of electricity generated should correspond with the surface of the articles to be coated, and that the intensity should bear reference to the state of the solution, that is to say, that the quantity should be sufficient to give the required coating of metal in a given time, and the intensity such as to cause the electricity to pass through the solution to the articles. It is also essential that the plates of metal forming the positive pole with the solution should be of corresponding surface to the articles to be coated, and face them on both sides, A rough idea may be given here of a plating vessel which is about 6½ feet in length by 33 inches in breadth and 33 inches in depth, and contains from 200 to 250 gallons of solution; the silver or nickel plates serving as electrodes. Two battery troughs are arranged so as to consist of six batteries of three pair intensity. The zinc plates, immersed in the acid from which electricity is disengaged, and the electrode exposed to the articles receiving the deposit, being in proportion.

The vat should contain the solution with the battery having the zinc pole inverted, connecting with rods upon which the articles are to be suspended with wires, and a copper pole is then connected with the electrode. So soon as the articles which are connected with the negative pole of the battery and the electrode connected with the positive pole are immersed in the solution, the galvanic circuit is completed.

To ascertain the amount of metal deposited, it is well to weigh such articles carefully before and after the operation is completed.

Description of an extensive establishment of nickel plating in actual operation for saddlery, hardware, sadirons, bits and turrets, and where 500 lbs. material are daily plated, finished, and brought to market:—

1. It consists of a large wooden box, which is five feet six inches long, fourteen inches deep, and two feet wide, lined with asphaltum varnish so as to be perfectly tight.

2. The capacity of the box is seventy gallons liquid, consisting of hot water, in which three-quarters of a pound of the double salt of sulphate of nickel and ammonia to each gallon are dissolved.

This vat is connected by wires with (3) a *Smee battery*, consisting of six zinc plates, 9×10 inches, which are previously well amalgamated with mercury, (4) and six carbon plates, likewise 9×10 inches. This box may be lined with lead and must contain ten gallons of water, to which twenty ounces of oil of vitriol are to be added. The carbon plates are now put between each zinc plate, and will keep up the evolution of hydrogen gas as soon as put in connection; it will remain in active operation for two weeks, while the zinc plates need no reamalgamation for four months.

5. Copper or brass wire is stretched across the decomposing or plating vat, for suspending the various articles to be plated, which, according to the power of the battery, takes from six to ten hours, but the average will be eight hours. It is fully understood that the ware must be perfectly clean, free from grease or dust before introducing them into (6) the bath. After being taken out from the plating liquid, the articles are washed off with hot water, and polished on a cloth buff with crocus, rouge, Vienna lime, or other polishing powder and oil.

The expense attending the nickel-plating is quite inconsiderable; spoons and forks may be coated completely with nickel for 25 cents per doz.; turrets or check holders, wheel hubs, large bits, and other saddlery trimmings, for 30 cents per doz.; a sadiron, weighing five pounds can be plated for four cents.

The operation is constantly going on; as soon as one set is sufficiently coated it is removed and replaced by another.

The main condition of nickel-plating lies in these points: 1, to have the solution always kept neutral, it is necessary to test frequently the liquid by means of litmus paper, and if the same indicates a prevalence of acid, to add sufficient caustic ammonia to make the liquor perfectly neutral; also to replace occasionally the consumed salts; 2, to have the materials to be plated always perfectly clean, which, if the goods are of iron, can be done by dipping them in a mixture of muriatic acid and water; the least scratches will prevent a complete coating.

Number 30 brass wire for small articles, and number 16 wire for larger copper articles, are used for suspending the ware.

The chloride of nickel and ammonia is much used for plating, requiring but four ounces of the salt to one gallon of water.

A simple nickel-plating apparatus, likewise in full operation, may also be described, as very satisfactory results are daily realised: 1, a bath or vat containing the usual nickel solution of double salt, three-quarters of a pound to the gallon of hot water; five gallons is applied to the porous cell which contains the amalgamated zinc pole three inches broad, seven inches deep, and seven inches long, but touching within one-half of an inch all around from the cell. The copper wire is connected, to hold suspended the articles, such as faucets, pistols, or other ware to be plated with nickel; the operation goes on at once and deposits the metallic nickel from its solutions in the space of three to four hours.

In a synopsis of Adams's claim of nickel-plating for which he obtained four patents, I find that he bases the one of August 3, 1869, on a solution of the double sulphate of nickel and ammonia, and of a solution of the double chloride of nickel and ammonia; the patent, March 22, 1870, on the solution of the double sulphate of nickel and magnesia; and in that of May 25, 1870, for a solution of the double sulphate of nickel and ammonia; while his last patent of March 11, 1873, he claims a solution of either of the soluble salts of nickel, which must be free from the presence of potash, soda, lime, alumina, and nitric acid, or either of them, and free from acid and alkaline reaction, or from either. It appears, therefore, that they are all tending to prove the character of the solutions he uses for depositing the nickel, which, however, have been very clearly described by George Gore, in 1855, and the application of the double salts are published by Smee. Booth's "Dictionary" for 1852 speaks of a nickel battery consisting of either the nitrate or sulphate of nickel and ammonia being used for plating. The preparation of pure metallic nickel, whether from the ore or by re-casting of such granular nickel as is manufactured in Camden, N.J., or as is imported from the English and German manufactories, is generally considered to be a known metallurgical process. Whether the nickel metal contains some carbon or iron, if used as anode, matters little, for it does not affect at all the operation of plating.

M. Becquerel states that any one may apply the process which Mr. Adams has patented without any infringement; as potash in no way affects injuriously the deposition of nickel, the double sulphate of nickel and potassa as well as the double sulphate of nickel and ammonia can easily be applied; while the special feature of Mr. Adams's patent consists in the exclusion of the smallest quantity of potash, soda, or other alkaline earth from the bath, containing the nickelising preparation, pure double chloride of nickel and ammonium or the perfectly pure sulphate of nickel and ammonia may therefore safely be employed.

Nagel's process for electro-plating with nickel or cobalt is likewise based upon applying the double salts of sulphate of nickel and ammonia or double salts of sulphate of cobalt and ammonia with the platinum positive pole. It consists in taking 400 parts of the sulphate of nickel and 200 parts ammonia, dissolved in 6000 parts of hot water and the ammonia of 0·909 spec. gravity, heated to 100° F.; and if cobalt, but 138 parts of the sulphate of double salt are employed.

Mr. Beardslee, who is unquestionably the veteran in nickel plating in the United States, informs the author that ever since 1858, he has coated metals with electric currents; that he found the chloride of nickel with a certain quantity of ammonia to be of great service,

He attributes any failures in depositing nickel to the following requirements:—

1. Nickel must have a perfectly uniform and unchanging current of electricity; a Smee battery, with a chromium negative plate, gives a powerful and constant current of electricity.

2. The nickel solutions with the chloride solutions may work better with acid instead of alkaline reaction; he quotes, as instances, that he had 2000 gallons of nickel solutions since 1868 and 1869, in constant use without any addition, but have been corrected from time to time in order to give them an acid reaction, as the tendency in working is to become alkaline.

The author begs, however, to close this pamphlet and the subject of nickel plating, by remarking that sulphate of nickel and ammonia will work better if kept under an alkaline reaction.

The following remarks, given to the author by Mr. Beardslee, are of much importance to those who wish to be fully posted:—

He uses two cells of the chromium negative plate battery; the amount of battery power required for a given quantity of work to be done should be in zinc surface, equal to the surface to be quoted.

The surface of the nickel anode should in no case be less than the surface to be coated. The anode surface for a nickel solution may be much greater than the surface to be coated; and more and better work will be the result.

For a nickel solution of 40 gallons, 10 anodes of 6×12 inches are required, and in proportion to the greater or less quantity of gallons. By estimating 7½ gallons to each cubic foot, we can determine the amount of solution that will be required for a vat of any given size.

The nickel anodes are connected with the negative plate of the battery, which may be either the chromium or carbon plates; the articles to be coated are connected with the zinc pole of the battery.

In one gallon of the nickel solution, a nickel anode of 4×6 inches is employed for coating small articles from two one-gallon cells of the chromium negative plate battery.

Stolba's method of nickel-plating by means of chloride of zinc has lately been introduced for coating iron, steel, copper, brass, zinc, or lead. He recommends the chloride or sulphate of nickel as simple salts (which need not be chemically pure).

To a portion of chloride of zinc twice the volume of water is added, the mixture is then boiled, and hydrochloric acid is slowly added, until the precipitate formed by the dilution re-dissolves again. A very little zinc powder is added, and in a few minutes the vessel is coated with zinc wherever the liquid is in contact with it. Nickel salt is then added to it in sufficient quantity to impart a green tint to liquid. The articles to be plated are then introduced, along with a few cuttings of zinc, making as many points of contact as possible; the mixture is to be boiled for about 15 minutes, when the coating is complete.

The American Government contemplates running a line of telegraph along the coast of New Jersey from Sandy Hook, at the entrance to New York Harbour, to Cape May, at the mouth of the Delaware. This line is to connect the various life-saving stations on the New Jersey coast, and it is to be used to order the display of cautionary signals. A similar survey has been made along the coast of Massachusetts for the same purpose.

LIGHTNING AND LIGHTNING-RODS.*

By JOHN M. MOTT.

(Continued from page 283.)

A knowledge of the laws of electrical induction, accumulation and conduction, together with a clear understanding of the action and value of points, will enable us, without difficulty, to arrive at correct conclusions in relation to the application of lightning-rods to buildings. The free electricity with which buildings are charged by induction will, in every instance, accumulate with the greatest intensity upon the ridges and gables, sometimes with greater intensity at one gable than at another. It is therefore absolutely necessary to place a point at each gable, to discharge the accumulated electricity there held by the opposite force contained in the approaching cloud; to place a point at each chimney or ventilator, to offer a line of superior conduction to that offered by ascending smoke, current of heated air, or other gaseous matter; to connect all these points together with rods placed along the ridges, and also to connect them with the gas pipes, water pipes, steam pipes, speaking-tubes, or other metallic substances about the building. The more numerous the connections with the earth the better, not only to provide sufficient lines of conduction, by means of which we may so far neutralise the passing cloud as to prevent a disruptive discharge, but also to give the electrical agency an ample line of conduction, so as to prevent intermediate explosion during its transmission. As we depart from this system of applying rods the protection diminishes. Each ground rod should have several branches penetrating the earth to permanent moisture, and where it is difficult to obtain such a termination, they should be imbedded in charcoal. An improper termination of a lightning-rod is to connect it with the gas or water pipes of a city or village beneath the surface of the earth. Theoretically, it is the best possible termination; practically, one of the very worst.

The experiment of Coulomb demonstrating that free electricity resides almost exclusively upon the surface of an *insulated* conductor has proved to be as much a stumbling-block to many electricians as the one fluid theory of Franklin, and his theory of the action of points upon electrified clouds. Since the molecules in the interior of a conductor discharge with equal readiness on every side, there is no chance for them to become charged; but at the surface of an *insulated* conductor the molecules have conducting molecules upon one side of them, and non-conducting molecules upon the other side; hence their polarisation must be followed by the charged state.

Trees near dwellings do not, as many suppose, afford protection; on the contrary, they increase the danger to persons or property in their vicinity and the necessity of using lightning-rods to prevent damage. They offer facilities for a direct discharge, consequently objects near them are in great danger from the return stroke. The fact that trees are injured by lightning is proof that they are poor conductors, while the large numbers of persons and animals annually killed near them by this same element is conclusive evidence that they do not afford the protection claimed.

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* Abstract of a paper read before the Meteorological Section of the Franklin Institute of Philadelphia. From the "Journal of the Franklin Institute."

In newly settled countries the cabins are usually provided with stoves, the pipes of which project through the roof; while these pipes do not in the least attract electricity, they furnish a path of less resistance than that of the surrounding air for its passage, the effect of which has often proved fatal to the occupants.

Barns are very frequently destroyed by lightning. This is owing to several causes: first, efficient lightning-rods have not been erected in a proper manner; second, the combustible material they usually contain and the comparative ease with which it is ignited; third, they are sometimes filled with hay or grain imperfectly cured or dried, and are also not unfrequently left during the season of thunder-storms surrounded by decomposing vegetable and animal matter. These substances ferment, or "heat," as the farmers term it, and as the gas or vapour rising from the mow or yard into the atmosphere above the barn furnishes a line of less resistance than the surrounding air, it becomes a part of the line of discharge when the cloud approaches sufficiently near so that the electrical attraction between the opposite electricities can overcome the resistance.

The annoying and disturbing effects of lightning upon the telegraph are caused by conduction and induction, A charged cloud often covers a space of a hundred square miles or more, extending over lines of telegraph, The point of disruptive discharge may be at a distance of many miles from the wires. When the cloud is over the wires they become charged by induction, and when the discharge ensues, from any point, induction instantly ceases and the wires return, like other objects, to their normal condition.

The effect of this return is often observed upon the instruments when the operator is too far from the point of the discharge to see the flash or to hear the report.

Mr. Crosse, of Bloomfield, England, has, by means of wires about one-third of a mile in length, insulated, and supported by means of poles and trees in his park, frequently succeeded in conducting from the atmosphere sufficient electricity to charge and spontaneously discharge a battery of fifty Leyden jars, containing seventy-three feet of coated surface, twenty times in a minute, accompanied by reports as loud as those of a cannon. Telegraph wires conduct free electricity from strata of charged atmosphere in the same manner as the suspended wires of Mr. Crosse, and as the insulators become covered with a thin film of moisture, by the condensation of aqueous vapour, they allow the electricity to pass from the wires to the poles, and as these are imperfect conductors the phenomenon of a disruptive discharge frequently occurs, attended with its well known consequences. If each pole had a wire extending its whole length, attached to it by means of a few small staples, such phenomena would be entirely unknown.*

The free electricity from charged strata of air is frequently conducted by the wires into the office in such quantities as are sufficient to melt the fine wire of the instruments.

It is by making a practical application of our knowledge of the effect of points when attached to charged bodies, namely, increasing the intensity sufficiently to cause a free discharge at any given point, that the instruments and operators are preserved from destruction by lightning.

Oil tanks about the oil distilleries have been exploded; fires have ensued involving great loss, supposed to have originated by the tanks being struck by lightning. These tanks are immense air-tight vessels, with the upper portion in the form of a dome.

The lighter portions of these coal oils rise to the top of the dome. These volatile oils are very inflammable, and when mixed with air are as explosive as gunpowder. The atmosphere about the tanks is filled with gas from these oils. The iron tank being a good conductor, well connected with the earth by means of the pipes running to the distilleries, would be easily charged by induction in case a charged cloud should be near it. Its form is such as to secure the maximum amount of accumulated electricity. The tank itself will not offer the least possible attraction for the electricity of the cloud, while the free electricity with which it is charged, by induction, offers great attraction. If a discharge should occur, the inflammable gas about the tank would be ignited before the electricity would reach the tank, and the most disastrous oil explosion and conflagration would ensue, notwithstanding the fact that the tank has sufficient conducting power to conduct with safety every discharge of electricity which may fall upon it from now to eternity.

This tank, which seems, to persons not conversant with electrical laws, to be most safe from injury by lightning, is known, by those who are familiar with such subjects, and who exercise their reasoning faculties, to be exceedingly defected, and in imminent peril during the passage of electrified clouds. A rod of iron or copper, attached to the dome and terminating in a finely plated point, would be a part of the tank, and would perfect its construction. The tank would not now remain in a charged condition; hence there would be no attraction about it. The point would permit a flow of electricity from the earth towards the cloud, and would tend to prevent an explosion. Oil tanks thus protected would not be injured by lightning.

To escape injury from lightning, protect buildings as herein directed, and remain in them during thunder-storms. Keep out of cellars, and avoid being near trees during the passage of electrified clouds. In case the gas or water pipes of a building are not connected with the lightning-rods, it is not safe for a person to remain in a position in which his body would become part of the line of least resistance between them. Beds should be removed from the walls. Persons in chairs should be in the centre of the room, and keep their feet off the floor.

The height a rod extends above a building has no influence whatever upon a discharge of electricity further than arises from the fact of its offering a path of less resistance than the surrounding air before the discharge takes place. It is for this reason, solely, that the rod is carried a short distance above the ridge of a building, and is projected above the tops of chimneys, ventilators, &c. It cannot be supposed for a moment that an agency which moves with such terrible velocity and irresistible force as lightning, could be arrested in its onward course and drawn aside by an insignificant piece of metal in the form of a lightning-rod. If metal does possess this power of arresting lightning, the use of metallic eave-troughs, steam pipes, gas pipes, water pipes, speaking tubes, bell wires, bells, valleys on roofs of buildings, chimney tops, cornices, &c., in and about buildings, should be at once discontinued, as they may attract more electricity than they can carry off. The idea that metal attracts electricity is unsupported by any fact, and is absolutely at variance with the whole course of experience. Such an opinion has arisen entirely from assumption and a partial consideration of facts, or from superstition, prejudice, or unadulterated ignorance. Lightning-rods do not attract lightning. They have no influence whatever upon a thunderbolt after it has started, to restore the equilibrium. The height they project above the building is of but little consequence, providing they be kept *low enough* to withstand the storms. There is no law governing the lateral extent to which a rod affords protection, this being dependent upon the form of the object to which it is applied and the position of the electrified cloud.

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* The writer seems to be unaware that this principle is adopted. —Ed.

Summary.—Insulators, glasses, at the points of support, are of no use in any case; they destroy the most valuable influence of the rod, and may, under certain circumstances, be the cause of most terrific and destructive return strokes.

The conducting power of lightning-rods is proportional to their solid contents, or sectional area, with similar metals of equal lengths, and not to their surfaces.

A lightning-rod should have the conducting power of a copper-rod one-half inch square, and perfect metallic union of all its parts. A rod made exclusively from copper wires, if of sufficient size, constitutes one which is perfect in theory.

Sharp points for the upper termination of rods are necessary. Rods are of but little value without them. Points should be plated, to prevent oxidation. They are also of value when used at the lower terminus of the rod.

It is necessary to place a point at each gable, chimney, and ventilator; to connect all together; to connect the rod with metallic roofs, gutters, valleys, steam pipes, gas pipes, water pipes, speaking tubes and other permanent metallic bodies about buildings, and the more numerous the connections with the earth the better.

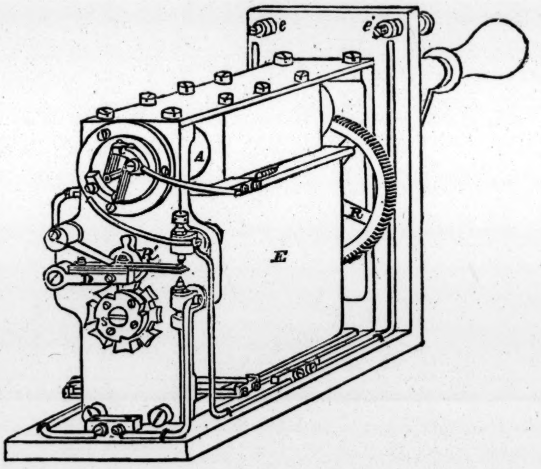
Ground rods must have two or more branches penetrating the earth to permanent moisture; must extend below the foundation walls or the bottom of the cellar. In some instances, where it is difficult to reach moist earth, they must be imbedded in charcoal.

On Thursday, the 9th inst., the workmen of the Penygraig Colliery, Rhondda Valley, presented a testimonial to R. Rowlands, Esq., manager of the colliery. The testimonial consisted of an illuminated address engrossed on vellum by Mr. Daniels, of Liverpool—a handsome watch and chain each for Mr. and Mrs. Rowlands—and a purse containing about £150. The watches were Keyless English ¾-plate Levers, with chronometer adjustments for temperatures, and specially manufactured by Mr. Streeter, of London, the one presented to Mr. Rowlands bearing the following inscription:—"Cyflwynedig i Mr. Rowland Rowlands gan weithwyr Glôfa Penygraig a chyfeillion ereill.—*Observer, October 19th*, 1873.

SIEMENS'S DYNAMO-ELECTRIC APPARATUS.*

In the earlier Siemens's Magneto-Electric Machines the inductive action of permanent steel magnets on a revolving Siemens's armature was employed for generating the currents. In the machine to be described electro-magnets are employed instead of permanent steel magnets; the residuary magnetism left in the coils of the electro-magnets, after a current from even a single voltaic cell has been once sent through them, is found sufficient to always have the necessary inductive action on the armature. This inductive action, although very weak at first, generates slight alternating currents in the armature, which are, by means of a commutator, caused to flow always in one direction through the coils of the electro-magnet, thereby increasing the magnetism in the core, which, in its turn, increases the inductive action, causing stronger and stronger currents to be generated in the armature. The magnetism in the core and the induced currents in the armature act and react on one another till the limit of the magnetic capacity of the core is reached. If the coil of the armature is then suddenly connected with a telegraph line, instead of with the coils of the electro-magnet, a short but very powerful current will be sent through the line. If this line is interrupted somewhere for a very short distance, or if its resistance is greatly increased at some point, as by putting a short piece of some badly-conducting material between the ends of the good conductor, a spark is caused to pass between the ends of the good conductor, or the piece of bad conductor is greatly heated, causing its ignition if it is susceptible of being easily fired, as is the case with the composition employed for the purpose in Abel's fuses.

Fig. 1.



This instrument is besides suitable for releasing clock-work at considerable distances. When used for this purpose, one terminal is to be connected to the line wire, and the other to earth, and the handle of the machine turned when it is desired to send a current.

The general appearance of the Dynamo-Electric Machine, with its cover off, is shown in fig. 1, where A is the revolving armature, on the axle of which is a pinion, driven by the wheel R, which is turned by the handle at the end of the machine, E is the electro-magnet, and C the commutator. The lever D, when in the position shown, establishes short circuit between the coil of the armature and the coils of the electro-magnet; but, after each two revolutions of the wheel R', which is fastened on the same axle as the wheel R, the tooth under the lever falls into one of the notches in the cam S, and thereby causes the upper spring at the end of the lever D to leave the upper contact screw, thus breaking the short circuit, and causes the lower spring to come into contact with the lower contact screw, thus obliging the current to pass into the line, the ends of which are connected to the parts of the terminals *e* and *e'*, which are on the outside of the end of the machine, instead of into the coils of the electro-magnet.

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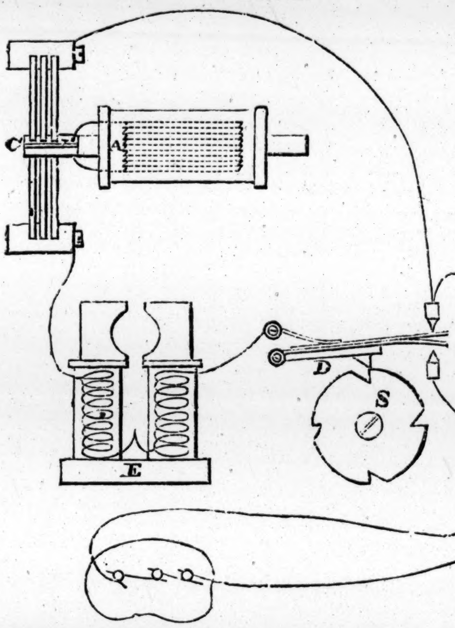
* Communicated by the Authors.

Fig. 2 gives a diagram of the connections of the instrument, the same letters of reference being employed to point out the different parts as in fig. 1.

FIG. 2.



When the Dynamo-Electric Machine is used as a mine-exploder, the leading wires to connect the machine with the mine to be exploded are inserted in the screws *e* and *e'*; but, to prevent accidents, this connection is not made until immediately before the fuse is to be fired. In order to obtain the whole power of the machine, the handle should be turned round three or four times *backwards* before firing the charge.

It is necessary that one at least of the leading wires should be perfectly insulated from the other, and from contact with the earth; but, in the case of the machine having to be used at a great distance from the mine to be fired, the earth may be used in place of one of the leading wires: if this is done care must be taken to make good earth-connections as for ordinary telegraph work.

It is better to use three or four Abel's fuses in each mine to be exploded, as, if only one is used, a misfire may occur, owing to the fuse having been spoilt.

If one mine only is to be exploded, the fuses should be connected up, so that the current will pass through one fuse after the other; but if more than one mine is to be exploded, three or four fuses should be placed in each mine, and the groups of fuses should be connected to the main leading wires.

Correspondence.

INSULATION.—OUR INDIAN TELEGRAPHS.

To the Editor of the Telegraphic Journal.

SIR,—In the extract given in your number of May 15th, from the *Telegrapher* of April 5th, 1873, headed, "*On Economical Line Construction*," Mr. Brooks, in the second column, enters into a consideration of the gain in money and loss in current produced by using for a land line a thin wire instead of a thick one. He states that when the absolute conduction resistance is increased 22 per cent. the loss so produced can be compensated for by increasing the battery power 22 per cent.

Now this is far from being the case in a long or badly-insulated line, since an increase on the conduction resistance not only diminishes the current leaving the sending station, but in addition diminishes the proportion of the sent current arriving at the receiving station, so that an increase in the conduction resistance produces a double diminution in the received or effective current. This will perhaps be more clearly seen from the following consideration.

Let the absolute conduction resistance of a line be (2 R), the absolute insulation resistance (B), the resistance of the relay at the distant end of the line (D), and the electro-motive force of the sending battery (E), then, if the line be uniformly insulated, and if we neglect the resistance of the battery itself—which is usually small compared with the other resistances in circuit—we have the received current equal to—

$$\frac{BE}{A(2B+D)+A^2+BD}$$

Now if (A) be not small in comparison with (B), which will be the case in a long or badly-insulated line, increasing (A) by 22 per cent will diminish the above fraction by *far more* than 22 per cent; consequently it will require that (E) should be increased by *far more* than 22 per cent to keep the received current constant. The use, therefore, of thick wire for long land lines possesses far greater advantages than Mr. Brooks has attributed to it.

This gentleman then proceeds to quote an article from "one of the London leading scientific journals," in which it is stated that "there is no place in the world where there is such a lack of scientific knowledge in connection with the telegraph service except America as in the British East Indies." Probably this gentleman is not aware that Mr. Latimer Clark (who, when on a visit to India, examined the telegraphs of that country), stated recently, while occupying the President's chair at the Society of Telegraph Engineers, that "although some six years ago the Indian Government Telegraph was, perhaps, one of the most unscientific in the world, that now it had attained the foremost place amongst telegraphic administrations in the application of scientific laws to practical questions."

Mr. Brooks seems also unacquainted with the "Instructions for Testing Overland Telegraph Lines," compiled by Mr. Schwendler, of the Indian Government Telegraph, and issued to the officers of that department June 18, 1869, since Mr. Brooks's "*Method of Determining the Actual Resistance of Old Telegraph Line Wires*," which he gives as new, in the *Telegrapher*, April 5, 1873, may be found not only *in extenso* in the "Instructions" referred to above, but, in addition, with what is most essential in practice (but what is not given by Mr. Brooks) methods for determining the exact position of the "single leak," and for freeing all the results from the effects of natural line currents.

If Mr. Brooks wishes to see what scientific work is being done, and has been done, by the Indian Government Telegraph, I would refer him to "The Instructions for Testing Telegraph Lines, and the Technical Arrangements in Offices," the first part of which was published in the beginning of 1872 by that department, the second and third parts being probably also now ready. These "Instructions," in three parts, are founded on those issued in 1869, but are much more elaborate and complete.—I am, &c.,

W. E. Ayrton.

Prof. Nat. Phil., The Imperial College of Engineering,
Tokei, and Hon. Sec. for Japan of the
Society of Telegraph Engineers.

Notes and Queries.

Boiler Crusts.

"Steam" asks what is the best kind of battery to attach to a steam boiler to prevent lime deposits? [A constant battery, such as Leclanché's or Daniell's, but we think so much battery power would be required that the application would not pay.]

Electrical Units.

"Honours Science Student" finds himself very much confused in trying to understand the B A units. He asks for information on the subject in the Telegraphic Journal, for the benefit of students like himself. The value of the various units he finds is so differently stated by various authorities as to make their comprehension almost impossible. For instance, Jenkin, page 162, says: "About one farad per second would flow if one Daniell's cell were employed to produce a current in a circuit, the total resistance of which is one ohm." From this he infers that an E. M. F. of one volt will send a current of one farad per second through a total resistance of one ohm. But Latimer Clark, in his work on Electrical Measurement, makes the farad to be something quite different. On page 44 he says: "The farad is that quantity of electricity which, with an E. M. F. of one volt would flow through a resistance of one megohm per second." Hence Jenkin's farad is a million times greater than Clarke's farad.

Societe Industrielle de Mulhouse.—Prize List.—Amongst the prizes offered for distribution, in May, 1874, are the following, which may be considered as relating or effected by electricity. Medal of honour for introducing or manufacturing in Alsace cylinders of cast-iron, covered with copper by electro-plating, which are to be used in printing calicos. First-class medal for a new indicator, specially designed for the spindles of looms, and capable of registering up to 10,000 revolutions a minute. First-class medal for an apparatus transmitting thermometrical indications to a distance.

A Race to the Telegraph Station.—The United States' Associated Press courier who carried the report of the Modoc execution from Fort Klamath to the telegraph station at Jacksonville, Oregon, rode 92 miles in 6 hours and 55 minutes, over a mountain road of more than usual roughness, employing only three well-selected horses for the journey. The last 42 miles, it is stated, he accomplished in exactly two hours, defeating his principal competitor by 30 minutes, and getting control of the wire, which was necessarily occupied in transmission of the Associated Press report until it was too late to forward any other.

Electrical Science in Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvii., No. 13.

Note upon Magnetism (Continued).—By J. M. Gaugain.—In the case of a permanent magnet, the curve that represents the currents arising from removal of the armature fall very rapidly from the extremity of the branches to the middle of magnet, and here sensibly coincides with the axis of abscissæ. In the case of an electro-magnet the curve of the currents arising from the removal of the armature differs little from a right line throughout the interval which separates the two bobbins; but this line parallel to the axis of the abscissæ is situated at a great height above the axis. In electro-magnets the increase of magnetisation that results from application of the armature is nearly uniform through the entire length of the horse-shoe. The current of demagnetisation that is produced by rupture of the inducing current, while the electro-magnet is without its armature, varies nearly as the intensity of the inducing current for a determined point of the electro-magnet. On the contrary, the current arising from removal of the armature is clearly proportional to the square of the inducing current. It results from this, that the relation of the current arising from the removal of the armature to the current arising from rupture of the inducing current varies as the intensity of the inducing current. I have found that the increase of magnetisation that is produced in a permanent magnet by the application of the armature is independent of the duration of the contact established between the armature and the magnet. In the case of an electro-magnet, the reaction produced by the application of the armature is completed in a very short time, but it is not instantaneous.

Les Mondes. Vol. xxxii., No. 5.

A New Battery.—By M. l'Abbé Moigno.—The Abbé Filhol has obtained possession of a Spanish mineral, a pyrites perhaps, with which it occurred to him that a battery might be constructed on the following plan:—At the bottom of a glass jar, he places a piece of zinc 20 centimetres long by 8 deep, and 4 across, forming a cup; in this cup he puts the mineral in question, and beneath it a copper plate; he fills the interstices with powdered coke, mixed with one-tenth part of chloride of sodium, or marine salt, and moistens with water. With four elements connected by insulated copper wires, copper to copper, zinc to zinc, he obtained a current of surprising energy, which gave large sparks at the contact of the poles, made an iron wire red-hot, violently rang an electric bell, gave shocks, &c. The Abbé Filhol does not hesitate to affirm that four new couples of equal dimensions display the energy of five couples of Bunsen, that his battery is well adapted to produce the electric light, and, what is more extraordinary, what seems incredible is, that after eighteen months' use of his battery, which he names Constant *Electrogene*, acted as well as on the first day, with the sole condition of keeping it very damp. M. Delaporte, electrical engineer, will shortly make a trial of this marvellous electrogene, and I will render a faithful account of it.

New Industrial Generator of Electricity.—A description of Messrs. Mure and Clamond's thermo-pile, described in this journal, page 11, vol. I.

Journal of the Telegraph. Vol. vi. Whole No. 142.

Management of Batteries.—By C. H. Haskins, Western Union Co.—The Hill battery, an American invention, has been in use for several years, with varying success. Since the introduction of the

Callaud, the same variety of opinion prevails with regard to its utility. Why this diversity of opinion? Simply, because the philosophy of action of the battery is not understood. A thorough knowledge of its peculiarities will enable any one to work and manage a gravity battery with entire success. And the foundation of it all, is this law: *The amount of current flowing to line is in inverse proportion to the resistance in the circuit.* And: The consumption of material is determined by the amount of current furnished to the line. Or, in other words, the chemical action of the battery is in direct proportion to the work performed. Hence it follows, that the amount of sulphate of copper converted or consumed in one battery, gives you no result from which to calculate the consumption in a battery on a line of different resistance. And this brings us to the foundation of all the trouble experienced. The jars have been charged with an arbitrary amount of sulphate of copper, regardless of the resistance of the circuit. The blue vitriol is dissolved by the water, and unless the action of the battery is sufficient to convert the vitriol as rapidly as it is dissolved, the blue solution will rise until it comes in contact with the zinc. In local batteries this is seldom the case; for the total resistance in circuit is but a few units, and the blue vitriol is converted as rapidly as it is dissolved. But batteries on main circuits are so choked back by the line resistance—unless the line is very short—that the vitriol is dissolved with greater rapidity than it is used. Consequently, the copper soon deposits upon the zinc discs, and the battery is ruined. My rules are: to drop a piece of vitriol of the size of a walnut, into each jar, when it is set up. Let this dissolve, then add small crystals, until the blue solution is, say two inches high, from the bottom of the jar. Instruct your battery man to add the crystals daily, keeping the solution as near as possible at the above height. Wipe off the outside of the jar, and the inside, above the fluid, daily, to remove the salt of zinc that may be deposited there by evaporation. When the sulphate of zinc solution becomes syrupy, like strained honey, or begins to deposit crystals on the zinc disc, draw off half of it with a syphon, made of twelve to eighteen inches of soft rubber tubing, and fill with fresh water. See that fresh water is added, to replace that lost by evaporation. Keep the battery room warm and dry. These rules do not require severe study, or a knowledge of chemistry. They are easily understood, and efficacious. I have yet to find any one so ignorant or stupid as to fail in applying them successfully. One battery, working two wires, was set up March 17th, 1872; another with four lines, July 1st, same year. These are both Callaud. A Hill, put up in July last year, is still working beautifully. Several others have been working from six months to one year each. None of them have been taken down, and all are clean, and working well. It is a mistake to suppose that the action of a sulphate of copper battery is increased by "crowding it" with an excess of sulphate of copper. So long as there is even a small portion of blue vitriol solution in the jar, its action is as vigorous as if there were a gallon. And I repeat, whenever there is an excess, and the consumption per minute is less rapid than the solution of the crystals by the water, this solution must rise until it reaches the zinc. The sulphate of copper is sparingly soluble in water, and when you lessen the external resistance, by adding lines, you soon reach the limit of its capacity to supply the blue solution as rapidly as it is needed. The average of lines to be worked economically from the sulphate of copper battery is four or five. I prefer the lesser number. As the internal resistance of a main battery is exceedingly small, compared with that of the line, it may be practically disregarded. I therefore use but one-fourth of a pound of sulphate of zinc to each jar, when setting up a new battery. Callaud's plan o lowering the zinc, to decrease the internal resistance in a main battery, is entirely useless, and from the loosening of the binding screws and consequent dropping of the zincs, this arrangement of hanging the discs is actually a detriment to the battery instead of an advantage. The only safe way is to hang the zinc the proper height, and then bend over the top of the suspending wire and cut it off, leaving it in the form of a hook on top of the binding screw. I have remedied this trouble in the zincs used by this company by casting a copper wire loop in the top of the stem, through which passes a round wooden rod, across the top of the jar. Thus the zincs are all at an equal distance from the bottom of the jar, and the internal resistance of all the jars must be alike. I use the same style and size of zincs, coppers, and jars, for main and local batteries.

Journal de Physique. September, 1873.

On a Modification of the Electric Thermometer.—M. Mascart.—This instrument consists of a helix of platinum wire joining two metallic armatures, and enclosed in a glass tube, the whole being supported vertically. Each of the armatures has a hook with ball, for the study of discharges of static electricity, and a binding-screw, for the study of currents. The upper armature has, besides, a tubulure, by which one may with a caoutchouc pipe put the air of the thermometer into communication with a manometer, so as to observe the changes of pressure produced by heating the wire. It is, in short, a Riess thermometer in which the mass of air is reduced as much as possible so as to obtain great sensibility. The apparatus may be made to record its indications, and for this purpose it communicates with a membrane and lever like those used by M. Marey in his physiological experiments. The membrane is of caoutchouc, stretched across a metallic capsule, and on it is a metallic plate, which acts, by a short point, on a very light lever. The small displacements which variations of pressure impress on the membrane are communicated to the lever, which magnifies them and inscribes them on the smoked paper on a rotating cylinder. The author reproduces the curves obtained from discharges of electric batteries and from continuous currents. There is (in the former) first a straight line, the tracing before discharge, then a curved rise and very gradual descent, showing the successive variations of pressure due to heating of the wire. It is noted that the heating of the air is not instantaneous; it quickly reaches its maximum, and then diminishes in a regular manner. The examination of the second part of the curve gives an opportunity to study the law of cooling. Further, with a constant charge the quantity of heat furnished by the spark diminishes when the number of jars is increased; and with the same battery, the heat of the spark increases rapidly with the charge. It is shown by numerical verification that the quantity of heat liberated is about inversely as the number of jars in the battery, and that it is nearly proportional to the square of the charge. A figure is given, showing the curves obtained by sending through the wire of the thermometer the current furnished by a Gramme machine worked at different velocities. Turning the machine with the hand, and observing a metronome, one is able to maintain a pretty uniform rate. The curves show that the heating of the wire is progressive, and that it takes a considerable time to reach its maximum. The quantity of heat liberated is, according to Joule's law, proportional to the resistance of the wire and to the square of the intensity of the current; if the intensity of the current is proportional to the velocity of rotation, the quantity of heat will be proportional to the square of the number of turns. This is confirmed by tabulated results.

City and Commercial Notes.

Telegraph Construction shares were pressed for sale on Tuesday, the 28th ult., on a rumour of a strike at the works. There was no foundation whatever for this report.

The Eastern Telegraph Company, Limited, have issued the following memorandum:—"On and after the 15th November next, *ten word messages for India* at the reduced rate of £2 will be accepted by the Eastern Telegraph Company at their station, 74, Old Broad Street, London, and at all the Postal Telegraph Stations throughout the Kingdom, when ordered *via* Falmouth, Four shillings will be charged for every word in excess of ten words. Negotiations have been for some time in progress with the Indian and other Governments for the introduction of a one-word tariff to India, Australia, and China, similar to that in force on the Anglo-American lines, but owing to the necessity of obtaining the general consent of all the contracting powers to the Convention of Rome, it is feared that the alteration cannot be brought into operation before the next International Telegraphic Conference, which will be held in 1875.—66, Old Broad Street, Oct. 22, 1873."

The Eastern Telegraph Company, Limited, have notified that their direct cable between England and Lisbon, as well as the cable between Vigo and Lisbon, is interrupted. Messages for the Peninsula are sent as usual *via* Vigo, while the traffic for Malta, Egypt, and the East is directed *via* Marseilles. The company's repairing ship, the *Hawk*, is engaged in repairing the direct cable, and will proceed in a few days to restore the communication between Lisbon and Vigo. The break in the direct cable is understood to be near the shore.

Reuter's Telegram Company and the Indo-European Telegraph Company, Limited, notify that the cable between Singapore and Hong Kong having been repaired, messages to China and Japan may now be again sent direct *via* Teheran."

A general system of telegraphic communication throughout Brazil is being rapidly and successfully completed. On the 14th of June last, the *Hooper* steamship left the Millwall Docks with the length of cable to be laid between Pernambuco and Para. She arrived at Pernambuco on the 30th July, and was joined by the *Great Northern* at Para on the 30th of September with shore ends. After having completed the section she returned to England, arriving at Millwall on the 4th instant, having made a very successful voyage. The *Great Northern* remained at Para for 30 days, when, the tests showing the cable to be in excellent condition, she returned with the electrical staff of the Hooper Company, arriving at Millwall on Monday, the 27th ult. The *Hooper* is now loading the second section—1500 miles in length—of the Brazilian cable in the Millwall docks, and she is to start on her important mission next Tuesday. Her work is to lay a cable from Pernambuco—where it will be joined up with the section just laid—to Bahia, and from Bahia to Rio de Janeiro. At the latter point the *Hooper* cable will be coupled up with the Plato-Brazilian Company's line, which company will lay a cable from Rio to Maldonado. From the latter point the Montevidean Company will lay a cable to Montevideo, which will be united to the Buenos Ayres cable which already exists in connexion with the Trans-Andine land line company connecting with Valparaiso. The Brazilian Submarine Company are laying a line from Lisbon to Madeira, and from the latter place to St. Vincent, and thence to Pernambuco. Thus, in a short time, the entire coast of Brazil and of the Argentine Confederation will be brought into direct telegraphic communication with England. In order to commemorate the successful laying of the first section of cable, and to wish good speed to the second, there was a general gathering of officers and gentlemen interested in the question of electric telegraphy on board the *Hooper* yesterday. Besides the gentlemen officially connected with the Hooper Company, who are manufacturing and laying the cables, and of the Western and Brazilian Telegraph Company, for whom they are being made and laid, there were present General Tremenhere, Colonel Milward, Colonel Campbell, Colonel Stotherd, Colonel Galwey, Captain Luard, Lieutenant Watson, Professor Abel, Sir F. Chapman, Mr. Danvers, of the India Office, Mr. Erichsen, representing the Great Northern Telegraph Company, and others. A general inspection of the ship by the visitors, and an examination of the various sections of *Hooper* cable already laid, was followed by a luncheon on board.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Oct. 30.
Stock	Anglo-American (Limited)	100	86½—87½
10	Brazilian Submarine..	9	2½—2 dis.
10	Cuba	All	8½—9
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	11	7—5 dis.
10	Eastern (Limited)	All	8½—8¾
10	Ditto New	All	—
10	Eastern Extn. Australia and China	All	8⅜—8⅝
10	Great Northern	All	8¾—9¼
25	Indo-European	All	15—17
10	Mediterranean Extension (Limited)	All	4¾—5¼
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	3½—2½ dis.
8	Reuter's..	All	10—11
Stock	Submarine	100	245—255
1	Do., Scrip-	All	2¼—2½
10	West India and Panama	All	5½—5¾
10	Do., 10 per cent Pref.	All	10—10½
20	Western and Brazilian (Limited) ..	All	12—14
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	92—94
10	Hooper's Telegraph Works	All	11¼—11¾
50	India-Rubber and Gutta Percha ..	All	29—31
Cert.	Submarine Cables Trust	100	108—110
12	Telegraph Construction	All	30¼—30¾
100	Ditto Ditto 7 per cent Bonds	All	102—104

THE TELEGRAPHIC JOURNAL ALMANACK.

We have to draw the attention of officers and others of the telegraphic community to the approaching publication of a professional almanack. We ask our readers to send *any* information that may appear to them to be useful for the purpose, so as to render the almanack as inclusive as possible.

Correction. — In Mr. Sabine's contribution on "*Earth Electricity*," in our last number, an omission had been made in copying the MS. which was not discovered in time for correction. At page 301, line 38 from top, instead of "a charged Leyden jar upon its surface," read "a charged Leyden jar, *when connected with the two poles of any source of electricity, but otherwise insulated from contact with objects*, upon its surface," &c.

To Correspondents.

Our "Students' Column" and the "Papers for Junior Students" are unavoidably crowded out of this number by press of other matter.

Prof. Ayrton (Japan).—The authorities for the statement to which you give a counter-quotation were Weber's "Researches" and Clark and Sabine's "Electrical Tables and Formulæ." The statement as to capacity supposes no absorption. We will call attention to the remarks.

F. E. S.—Apply to the makers of the cable. They will probably have a piece of faulty core by them.

Honours Science Student (No. 2).—The sentence is ambiguous: Evidently the meaning is that the values given result from actual experiment, not taking into account the different phases of internal resistance, &c., in the two cases. We do not follow your equation, nor the value obtained. Probably there is a slip of the pen, as the multiplication is at fault. Write again.

THE TELEGRAPHIC JOURNAL.

Vol. I.—No. 19.

THE TELEGRAPHIC ALMANACK.

When we announced the issue of a "Telegraphic Journal Almanack," we intended it to be an ordinary calendar, to which some useful information on telegraphic matters would be appended. But on commencing our work, we found that we could make the Almanack a valuable companion to the practical electrician by extending our plan so as to include tables arranged to assist in the construction, testing, and repair of telegraph lines. At the same time it was thought that, by giving the routes, tariffs, &c., of all the Companies, the Almanack would become a necessary adjunct to the offices of merchants and all others who require to use the telegraph wires or submarine cables. This extension was therefore decided upon, and there also has been added a map of the world, showing the cables already laid and those projected. The fact of the arrangement of the matter and the production of the lithographs being in the hands of Messrs. Grant and Co. is a sufficient guarantee of the pains taken in the compilation being supplemented by method and efficient workmanship.

As this extension necessitates a large outlay, it is impossible to present the Almanack to our subscribers as was intended. With the first number of our second volume, we shall publish a supplement consisting of the Almanack and Map, and a copious index to the first volume, the index being too lengthy for an ordinary number of the journal. This in itself will form a ready and complete record of events and progress in electrical science for the year. The price of the supplement will be 8*d*., making the charge for supplement and journal 1*s*.

This plan has been adopted solely in the interest of our readers, the cost of only the Almanack and Map being considerably in excess of the price charged for the supplement.

We have now cordially to thank our readers for the support which has enabled us successfully to grapple with the difficulties we have met with in our endeavour to establish a high class journal. In that endeavour we found determined opposition from quarters where we expected influence and official recognition, but this opposition has been outweighed a thousand times by the hearty co-operation of those eminent members of the profession whose contributions enrich the pages of our first volume and by the good wishes and support of our subscribers, who have increased to an extent that has for some time established the success of the journal as a fact. It is not, however, our intention to "rest and be thankful;" on the contrary, so long as our friends continue their support, so long will we strive to make our pages more and more useful. Telegraphy, and, indeed, all electrical science, has a great future before it. Our desire is to efficiently chronicle the events of that grand future as they pass, in the pages of "The Telegraphic Journal."

ELECTRIC CHRONOGRAPHS.

Major Navez, of the Belgian Artillery, who, in 1842, constructed a chronograph, may be said to be the first to successfully employ electricity as an aid to the measurement of small intervals of time. As such an aid, it is needless to dwell upon the advantages afforded by electricity; they are sufficiently recognised. In what follows, we shall confine ourselves to the description of the instrument, assuming the purposes to which it is applied—the measurement of the intervals of time occupied by bodies falling from a given height, the measurement of the velocity of projectiles, &c.—to be known.

In the chronograph invented by Major Navez, two wire screens, similar to that shown in Fig. 1, are arranged at a given distance apart in front of the gun. The passage of the shot through the first screen liberates in the chronograph a pendulum, to which a needle, carrying a vernier, is attached. The needle is thus set free to oscillate in the front of a graduated arc, until, at the passage of the shot through the second screen, an electro-magnet is excited, which clamps the needle. This apparatus of Major Navez was subsequently improved by an officer of the same service, Colonel Leurs, who gave to the resulting invention the name of the Navez-Leurs chronograph.

Instruments of this kind have also been invented by Colonel Benton, by Captain Vignotti, and Captain Martin de Brettes. In the Vignotti and De Brettes instruments, marking is effected by the spark from an induction-coil; the other method of marking is by electro-magnetic attraction.

Fig. 2 illustrates a Navez-Leurs chronoscope. This instrument consists of an upright vulcanite plate, with graduated arc, the plate and arc being mounted on a cast-iron stand. There are two pendulums, *a* and *b*, *a* being termed the chronometer, and *b* the register. The remainder of the apparatus consists essentially of two electro-magnets, a pair of springs, *c*, and the pivots upon which the pendulums and escapement system work. The chronometer pendulum carries an index-needle with vernier, and attached to the vernier is a small arc, upon which a stirrup, *d*, can be clamped. The wire being bound upon the screens, as shown in Fig. 1, and these placed in position with regard to the gun, the operation of measuring the velocity of the projectile proceeds as follows:—In Fig. 2 the battery-circuit which magnetises the chronometer-pendulum electro-magnet is represented by an unbroken line; the battery-circuit in connection with the register-pendulum electro-magnet by a dotted line. When the projectile passes through the first screen, the circuit is broken, and the electro-magnet of the chronometer-pendulum demagnetised. The chronometer-pendulum consequently falls, with its needle pointing along the arc. When the projectile reaches the second screen, and there severs the wires, the register-pendulum is liberated, and in its turn falls, during its descent knocking away the wedge-lever *d*, which holds the spring, *c*, open. The latter, in closing, clamps the needle of the chronometer-pendulum, and thus registers the arc through which the pendulum has fallen. This arc is the measure of the time elapsing from the piercing of the first screen by the projectile until the piercing of the second, plus the time occupied by the fall of the register-pendulum and the closing of the springs.

FIG. 1.

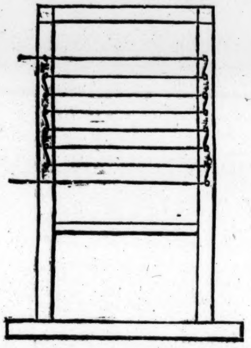
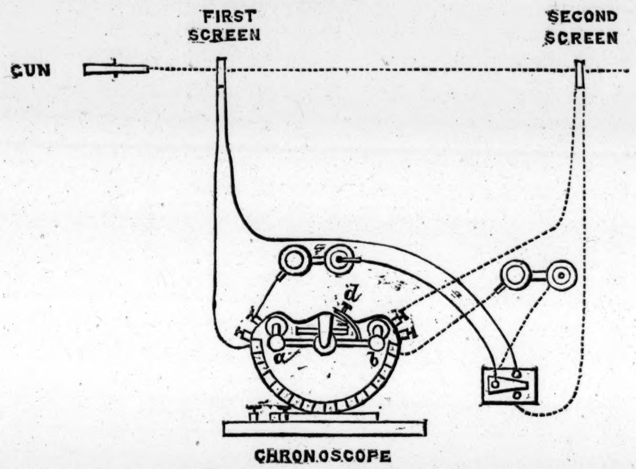


FIG. 2.



To ascertain how much of the arc of vibration is due to the mechanical working of the apparatus, both pendulums are liberated at once, and the time due to the arc thus found is subtracted from that recorded as above. These values are tabulated.

In the method of connection with the targets, as well as in the character of the targets or screens themselves, most instruments agree. The wire of the screens should not be more than 0·012 in diameter.

The disturbing influence brought to bear by the springs and other mechanical aids in the Navez-Leurs, Vignotti, and Benton instruments have been the subject of much discussion and of some objection. In Le Boulengé's * chronograph, however, the weight falls freely in a vertical direction, easily measured off upon a scale.

The Boulengé chronograph was first used in England in 1870 for various trials with the proof of gunpowder, and was then described by Captain C. Jones, R.A., Instructor to the Royal Gun Factories. Captain Michaelis's brochure may thus be regarded as an independent verification, and very interesting and important results does this verification introduce; for it bears out strongly the principle that simplicity in construction is the end of art. The description we give of this instrument must necessarily be confined to the mechanical detail; we cannot, of course, enter into the consideration of its constants, and the values to be obtained by it. Should we do so, we should break in upon another science than our own.

The front elevation of the instrument is shown in Fig. 3. A hollow brass column, S, supports two electro-magnets, A and B, and a small bracket, K. The column is based upon a triangular metal plate, clamped to the stand by three screws, *b*. This metal plate also bears a trigger. This trigger consists of a circular steel disc or knife, which can be disengaged by the fall of a weight. The electro-magnet, A, when charged, supports a long brass rod, C, hung vertically, and called the "chronometer." This rod is surrounded by two zinc tubes, D and E, called "recorders." By unscrewing the bob, P, at the end of the brass rod, C, the tubes E and D may be adjusted. The electro-magnet, B, when charged, sustains a shorter brass rod, F, termed the "register."

The operation of adjusting the instrument comprises:—(1). Levelling; (2). Regulating the power of the electro-magnets; (3). Fixing the height of the commutator reading, or taking the constant of the apparatus.

(1). The levelling of the instrument is effected by means of the chronometer rod, which for this purpose is attached to its magnet. When properly adjusted by the levelling screws on the base, the bevelled shoulder of the bob P should rest lightly against the projecting edge of the triangular base, while its left edge should be about one-fortieth of an inch from the corresponding edge of the base. In this position the edge of the cocked knife is brought within about the one-twentieth of an inch of the lower zinc tube. On falling the rod C is received in a leather bag fitting into the wooden stand upon which the apparatus is mounted. The rod F is adjusted in a similar manner, so that its bevelled edge rests lightly against the bracket K. On falling upon the plate O it works a lever and disengages the spring which governs the action of the knife. It is received on its fall, and thus prevented from tumbling on the floor of the instrument room, by the tube L.

In regulating the strength of the electro-magnets Captain Le Boulengé has adopted (says the *Engineer*, in which paper recently appeared a very full and independent report upon this instrument) the simple and ingenious plan of increasing the weight of the rod armatures by a small movable brass tube. The screwed cores of the electro-magnets are gradually withdrawn while the rods thus weighted are in suspension, until the armatures

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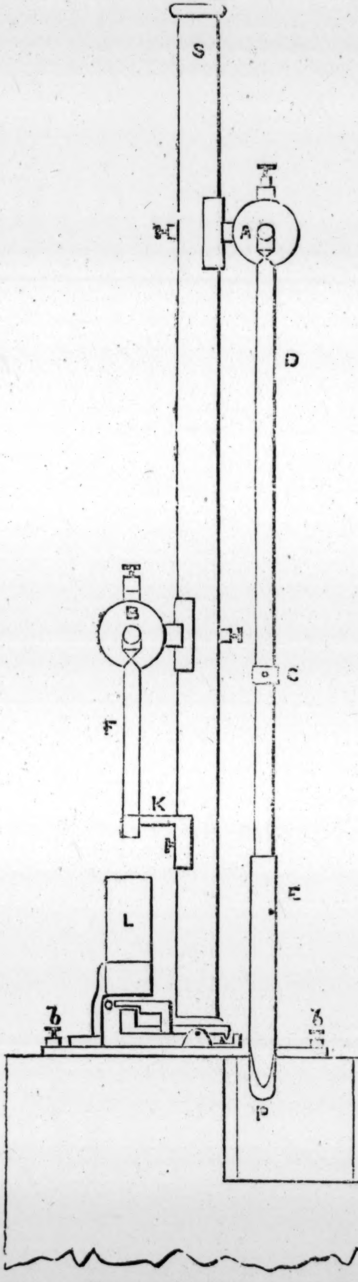
* "The Le Boulengé Chronograph." By Captain O. E. Michaelis, Ordnance Corps, United States Artillery. 1872. New York: D. Van Nostrand, 23, Murray, and 23, Warren Street.

Fig. 3.



fall. The extra weight is then removed, and the magnets are found to be just powerful enough to sustain the rods. If our readers have followed us thus far, they will have perceived that the instrument records by means of the knife, which on being liberated indents the zinc tube on rod C. In fixing the disjunctor reading the height of the knife dent on the lower zinc tube E should correspond to a time of 0·15 sec. This is the "constant" of the instrument, and its true position on the tube E is marked previous to an experiment. The height of fall of the rod F can be adjusted by turning the disc O, so that the knife shall indent the zinc exactly on the mark. Let us now assume that we substitute in Fig. 2 a Boulengé for the Navez-Leurs apparatus. The first circuit will include the first wire screen, the electro-magnet A, the disjunctor, and the two poles of No. 1 battery. The second circuit will include the second wire screen, the electro-magnet B, the disjunctor, and the two poles of No. 2 battery. On the breaking of the first screen by the shot the choronometer falls vertically; on the rupture of the second screen the registrar falls in its turn upon the disc O, depresses the free end of the lever, and thus releases the mainspring, the knife flies forward, strikes the falling choronometer, and indents the upper record or zinc tube D. Thus a record is obtained of the distance through which the chronometer falls during the fall of the registrar, plus the time taken by the projectile to pass over the space between the two targets. And, as we shall presently show, a very simple relation holds between the height of the dent thus obtained and the velocity of the projectile which caused it. If both screens were cut simultaneously the record on the rod C would be due to the time taken by the registrar to fall from its initial position to the disc O, plus the minute portion of time taken for the demagnetisation of B, plus the time taken in disengaging the catch of the lever, plus the time taken by the knife in passing over the horizontal distance which separates it from the chronometer, minus the minute portion of time taken for the demagnetisation of A. We shall call the sum of these times t. Since the chronometer follows the law of all falling bodies, the total time T taken by it in falling while firing a projectile through the screens will be found from the equation—

$$T = \sqrt{\frac{2h}{g}}$$

in which h is the distance (above the zero mark) through which the rod fell before the mark was made upon it by the knife. But this distance is also equal to t, the sum of the times as above, plus t^1 the time taken by the shot in passing over the space included in the two screens. Therefore $T = t + t^1$ and $t^1 = T - t$. As the disjunctor enables us to cut both circuits simultaneously the time t becomes simply the disjunction reading, which accordingly must be deducted from the whole time to arrive at the time taken by the shot to traverse the distance between the screens. The velocity in feet per second of the projectile, at a point midway between the screens, is of course found by dividing this distance in feet by the value of t^1 in seconds.

The following table gives the mean results of Captain Michaelis's experiments:—

Distance between turrets equal 100 feet.	Frankford Arsenal service cartridges fired from Springfield musket.	
	Schultz. feet.	Le Boulengé. feet.
Mean (arithmetical) velocity...	1225	1225
Mean difference of velocity ...	14·2	13·9
Probable error of signal result	±12·5	±12·8
Probable error of mean result	± 1·65	± 1·68

Captain Michaelis's remarks show that the Le Boulengé chronograph is as trustworthy an instrument for determining velocities as that most delicate and refined micro-chronometer the Schultz chronoscope.*

(To be continued).

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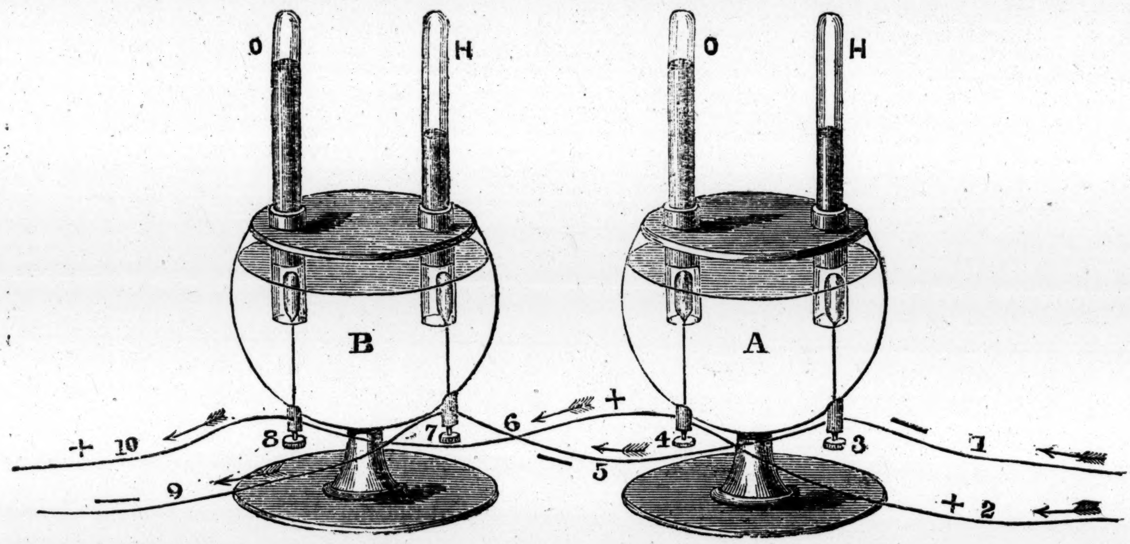
* In the Schultz chronograph the time is measured by the arc registered by two induction sparks on a revolving cylinder, the arc being converted into time by the undulating mark registered on the cylinder by a fork vibrating so as to give a musical note of known pitch.

A DISCOVERY IN THE SCIENCE OF ELECTRICITY.

By EVANS CASSELBERRY, of St. Louis, North America.

THE following is the explanation and description of a discovery which I have made in the science of electricity, and an explanation and description of the apparatus, instruments, process, and method by which I demonstrated and proved the same.

Description of the Apparatus.—The vessels A and B are glass vessels, usually called "decomposing cells," with lids or covers of glass. Through each of the glass lids or covers are inserted two glass tubes, O and H, closed at the upper ends or tops, so as to be air and gas-tight. The vessels, A and B, are filled nearly full with water, diluted or mixed with a small quantity of sulphuric acid, so as to facilitate decomposition. The glass tubes are also filled to the top with the same water that is in the vessels. The negative [−] wire 1, connects the binding-screw 3 of vessel A with the negative pole of a galvanic or voltaic battery, or with a magneto-electric machine, sufficiently powerful to decompose water easily, and the positive [+] wire 2 connects the binding-screw 4 which enters vessel A with the positive pole of the same battery or machine. The screw 3, which enters vessel A, connects by wire 5 (conducting [−] negative electricity) with screw 7, which enters vessel B. The screw 4 of vessel A connects by wire 6 (conducting positive [+] electricity) with screw 8 in vessel B. All of the wires and screws are metallic. The screws 3 and 4 in the bottom of vessel A each connects inside of vessel A with a platina wire. The screws 7 and 8, in the bottom of vessel B, each connects inside of vessel B with a platina wire. The wires in the decomposing cells are of precisely the same length, thickness, and size in every respect. The number of decomposing cells similar to vessels A and B may be increased to any extent that may be desired, and connected together in regular succession in the same manner in every respect that vessels A and B are connected. The wires connecting binding-screws 7 and 8, which are inserted in vessel B, show where and how the wire may be attached to connect the additional number of vessels.



Experiments with the Galvanic Battery.—I attached to the respective poles of a galvanic battery the respective wires, 1 and 2, which connect with the binding-screws, 3 and 4, in vessel A, and ejected into the vessel a negative current on the negative wire 1, and a positive current on the positive wire 2. These currents decomposed liquid in vessel A, and produced in *two* minutes *four* inches of hydrogen gas in tube H in vessel A, and *two* inches of oxygen gas in tube O in vessel A, whilst the two wires, 5 and 6, connecting vessels A and B, were detached from vessel A, so that vessel A, during the experiment, had no connection whatever with vessel B. I then attached both vessels together by fastening the respective wires 5 and 6, to the respective binding-screws 3 and 4, in vessel A, and to the respective binding-screws 7 and 8, in vessel B. Having thus attached both vessels together, I then again attached, as before, the respective poles of the same galvanic battery to the respective wires 1 and 2, which connect with the respective binding-screws 3 and 4 in vessel A, and again ejected into the vessel a negative current on the negative wire 1, and a positive current on the positive wire 2. These currents decomposed liquids in both vessels, and produced in *two* minutes *four* inches of hydrogen gas in *each* of the tubes marked H in vessels A and B (being *eight* inches of hydrogen in the aggregate), and *two* inches of oxygen gas in *each* of the tubes marked O, in vessels A and B (being *four* inches of oxygen in the aggregate). The number of cups, or pairs, in the galvanic battery which I used in trying the experiments mentioned in this section were neither increased nor diminished during the time of trying the experiments, but always remained the same, so that the quantity of zinc consumed, and the quantity of electric force exerted or expended during any given time, whilst trying the experiments, were always the same. The experiments in this section show that a galvanic battery, when attached to two decomposing cells in the manner hereinbefore described, produces twice the quantity of gas in two minutes that the same battery (containing the same number of cups or pairs) produces during the same time when attached to only one decomposing cell.

Experiments with a Magneto-Electric Machine.—The experiments in this section show that 211 turns of the crank of a magneto-electric machine, when attached to two decomposing cells in the manner hereinbefore described, produce twice the quantity of gas that the same number of turns of the crank of the same machine produce when attached to only one cell.

Experiments by Weighing the Zinc Consumed During the Decomposition of the Liquids.—I weighed the zinc consumed during the two minutes the current of the galvanic battery ran into vessel A alone, whilst vessel A was detached from vessel B; and I also weighed the zinc consumed during the two minutes that the current of the same battery ran into vessels A and B, whilst the two vessels were connected in the manner herein described in section one: and I found that there was as much zinc consumed during the two minutes that the current ran from the battery in vessel A alone as there was consumed during the two minutes that the current ran from the same battery into vessels A and B whilst the two vessels were connected together as described in the above-mentioned first section.

Summary.—It has always heretofore been supposed by scientists that when the wires of a galvanic battery, or magneto-electric machine, are attached in the usual manner to only one decomposing cell, that all of the electricity liberated by the battery, or machine, which enters the cell is consumed in doing the work of decomposition in this one cell, and that if an additional cell be added, as described in the first section, the electricity would be equally divided between the two cells, so that each cell would contain only one-half the quantity of gas that one cell would contain when used alone; but I discovered that the contrary is true, and that the above supposition is erroneous; and I also discovered that a galvanic battery, when attached to two decomposing cells in the manner described in section two, produces twice the quantity of gas in a given time that the same battery produces during the same time when attached to only one decomposing cell; that a given number of turns of the crank of a magneto-electric machine, when attached to two decomposing cells, produce twice the quantity of gas that the same number of turns of the crank of the same machine produce when attached to only one cell; and that there is no more zinc consumed in a given time, whilst the galvanic battery is attached to two decomposing cells, than there is consumed by the same battery during the same time when attached to only one cell. This process, or method of decomposing liquids by electricity, is infinitely cheaper than any other process or method heretofore known.

The experiments mentioned are the average results of a very large number of experiments performed by me between the middle of the month of September, 1867, and the middle of the month of September, 1872.

St. Louis, Sept. 29, 1873.

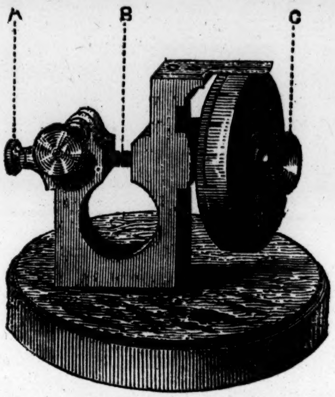
THE Director of the Imperial Russian Telegraph has given his consent to the transmission, free of cost, within the boundaries of the Russian empire, of messages announcing new astronomical discoveries.

THE telegraph is making rapid strides in South America. It is expected that in September, Valparaiso, Santiago di Chili, Buenos Ayres, Montevideo, Rio de Janeiro, Bahia, and Pernambuco, will be linked together by wires.

A NEW MICROMETER WIRE GAUGE.

By HORATIO YEATES.

IN practical work I have long experienced the want of a gauge for wires that shall measure both large and small diameters. Dissatisfied with those with which I was acquainted, either from their delicacy, complication of form, or expense, I endeavoured to provide myself with a gauge better suited to the rough and ready use of the workshop, but at the same time accurate. The form I am about to describe will, I think, be found simple and effective.



The thread of the screw B C runs one hundred to the inch. The micrometer head is divided into 100 parts. Thus each division indicates one ten-thousandth of an inch. The piece of steel A B is a cylinder (fitting in a thumb clamp), the axis of the cylinder being in a line with the axis of the screw. The end of it, as well as the end of the screw, is finished with spherical face.

To use the instrument, the micrometer head is turned to zero, and A B pushed up into close contact with the end of the screw. A B is then clamped in its place by the milled screw at the side. Now, by turning the micrometer head from right to left, the spherical faces at B separate; and when they are open just wide enough to allow the wire to be measured to pass, the diameter can be read off from the micrometer head at the index arm.

MATHEMATICS FOR NON-MATHEMATICIANS.

By W. PAGET HIGGS, LL.D., D.Sc.

DIVISION I.—THE ALGEBRA OF CONSTANT QUANTITIES.

(Continued from p. 316.)

Division, Fractions, and Ratio (continued).

IT is generally required, in any question where two or more quantities are concerned, to ascertain the relationship of these quantities. This relationship is henceforth known as the *difference*, or as the *ratio*. If of two sets, each set of two quantities, the differences or ratios are similar, then those quantities are said to be *proportional*, arithmetically or geometrically.

An arithmetical proportion is an equality of *differences*, or *equi-difference;* a geometrical proportion is an equality of ratios. $a-b=c-d$ is an arithmetical proportion; $a:b=c:d$ is a geometrical proportion.

When four terms or quantities are thus placed, the first and last are called the *extremes*, the second and third the *means*.

In an arithmetical proportion, the *sum* of the extremes is equal to the *sum* of the means; in a geometrical proportion, the *product* of the extremes is equal to the *product* of the means. Thus, with—

$$(1).\ a-b=c-d, \text{ and}$$
$$(2).\ a:b=c:d,$$

$a+d=b+c$, and $ad=bc$ in each case respectively. Thus it follows from (2), that when two fractions are equal, the numerator of one of them is to its denominator as the numerator of the other is to its denominator. And it also follows that a proportion may always be constituted with the factors of two equal products.

If four terms are proportional, they are proportional in any other order, so that we preserve similarity[*] in the order. Thus—

$$(a).\ 5:3::15:9$$
$$(b).\ 5:15::3:9$$
$$9:3::15:5$$
$$9:15::3:5$$

The position of the extremes is here unchanged, while that of the means is varied; this process was termed by the older writers on mathematics *alternando*, by the moderns *alternation*. Placing the extremes in the places of the means, as—

$$3:5::9:15;$$

this was called *invertendo*, and by the moderns is termed the inversion of the terms.

If there be two proportions (as (*a*) and (*b*) above), then, multiplying them term by term, the products are proportional (as $25:45::45:81$). This is the principle of the arithmetical process known as the "compound rule of three," or "compound proportion."

The process known in arithmetic as "rule of three," or "simple proportion," is derived from the fact that if one of the terms (x) of a proportion (as $a:b::c:x$) be unknown, it may be ascertained from the fact that a multiplied by x will equal b multiplied by c, and that to find the value of x, it is only necessary to divide the product of b and c by a; or $x=\frac{bc}{a}$. In other words, we multiply the second and third terms together, and divide by the first, to find the fourth term, or the answer.

In arithmetic, too, we are told that "the mean proportional between two numbers is equal to the square root of their product." The reason we may perceive from the following proportion:—

$$a:b::b:c.$$

Here b is what is termed a mean proportional. The product of the means is b^2; and we know that $b^2=ac$, the product of the extremes. To find, then, the mean proportional to ac, we take the square root of the product; for, if $ac=b^2$, then $\sqrt{ac}=b$.

Indeed, by deducing different equations from the equal ratios (or fractions) $\frac{a}{b}=\frac{c}{d}$, we may arrive at endless sets of proportionals. Professor Young says very clearly upon this point:—

"If two fractions, $\frac{a}{b}$, $\frac{c}{d}$ are equal, then we may replace the terms a, b of the first by any expressions involving a and b that are *homogeneous*[†] in reference to these quantities, provided we also replace the terms $c\,d$ by expressions involving c and d in the same manner. For instance—

$2a^2-3ab+b^2$ is homogeneous as respects a and b, each term being of two dimensions; so also is $5ab+4a^2-2b^2$: we may therefore substitute these or a and b, provided we put the similar expressions, $2c^2-3cd+d^2$ and $5cd+4c^2-2d^2$ for c and d; that is, we may infer that because—

$$\frac{a}{d}=\frac{c}{d}\therefore\frac{2a^2-3ab+b^2}{5ab+4a^2-2b^2}=\frac{2c^2-3cd+d^2}{5cd+4c^2-2a^2}$$

The reason of this is pretty obvious; two fractions cannot be *equal* unless one is convertible into the other by multiplying num. and den. of the former by some factor (m); so that in the above, c must be$=ma$ and $d=mb$. Now if in the *second* of the changed fractions above you put ma, mb for their equals c and d, you will see at once that that fraction will be nothing but the *first* fraction with its num. and den. multiplied by m^2. If the homogeneous expressions chosen for the terms of the first fraction had been of *three* dimensions, then after the substitution of ma, mb, for c, d in the similar terms of the second fraction, the result would have differed from the first fraction only by the num. and den. being multiplied by m^3, and so on, as is obvious. The particular case of this general theorem which is most frequently employed is this, namely:—

$$\frac{a}{b}=\frac{c}{d}\therefore\frac{a\pm mb}{a\mp nb}=\frac{c\pm md}{c\mp nd}\cdot$$

or, from $a:b::c:d$

$$\therefore a\pm mb:a\mp nb::c\pm md:c\mp nd$$

where the values of m and n are arbitrary. In most applications they are chosen each equal to 1, or one equal to 0, and the other equal to 1. I need scarcely mention, that when any of the conditions of a question are expressed by a *proportion*, the product of the extremes equated to the product of the means converts the proportion into an *equation*."

We may conclude this section with an illustration of the every-day use of the principles of ratio and proportion. There are, however, so many applications of the common principle of "rule of three" (which with too many of us is also "rule of thumb"), that we must look somewhat higher than the hackneyed but still valuable problem:—"If so many men build a wall in so many days, how long will so many more men take to build the same quantity of wall?" To the scientific student a very useful application is that known as the *Chain Rule*.

This rule is employed by the computer when he wishes to ascertain the value of one unit in terms of another, whether the unit be one of commercial exchange or of physical measurement. Thus, were it required to convert miles into inches, we should state the ratios as they follow—

$$\frac{\text{miles}}{\textit{yards}}\times\frac{\textit{yards}}{\textit{feet}}\times\frac{\textit{feet}}{\text{inches}}=\frac{\text{miles}}{\text{inches}}$$

$$\frac{1}{1760}\times\frac{1}{3}\times\frac{1}{12}=\frac{1}{63360}$$

By cancelling the factors in *italics* (the intermediate terms) it is seen, in the first instance, that we have the required ratio, which we obtain arithmetically, in the second instance, by the rule for the multiplication of fractions (see p. 315). The ratio of a mile to an inch is as $1:63360$.

Now if it were further required to reduce miles per hour to metres per second, it would be necessary to state the following ratios :—

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[*] Two extremes or two means are "similar" terms; an extreme and a mean "dissimilar" terms.

[†] Of like kind.

$$\frac{\text{hours}}{\textit{mins.}}\times\frac{\textit{mins.}}{\text{secs.}}=\frac{\text{hours}}{\text{secs.}}$$

$\frac{\text{miles}}{\text{inches}}\times\frac{39{\cdot}37}{1}$ (39·37 being the number of inches per metre).

$$\cfrac{\frac{1}{60}\times\frac{1}{60}=\frac{2600}{1}}{\frac{1}{63360}\times\frac{39{\cdot}37}{1}=\frac{3937}{63360}}=\frac{63360}{39{\cdot}37\times3600}=\frac{63360}{141732}={\cdot}447$$

the constant required to convert miles per hour to metres per second.

Another example will show the high importance of the principles we have studied. Suppose that the problem were put to us to determine the law which prevails between the resistances of bodies moving in the air, and their velocities. Let V[*] v be any two velocities, and R r the corresponding resistances: the problem is to find to what power of V is R proportional? Let us put x to represent this unknown power; then if any law should hold good, we have—

$$\left(\frac{v}{V}\right)^x=\frac{r}{R}$$

According to the rules for logarithms (see Rule III., p. 232), we have—

$$x\times\log.\frac{v}{V}=\log.\frac{r}{R};\text{ or}$$

$$x=\frac{\log.r-\log.R}{\log.v-\log.V};\text{ or}$$

the difference of the logs. of the resistances, divided by the difference of the logs. of the velocities, will give the required power of x. In reference to the motion of projectiles and of cars on railroads, this formula occurs not unfrequently.

As a commercial example, the case of simple interest may be selected as an instance of the use of proportion. Thus :—

To find the interest of a given sum, we say—

As 100 : rate per cent. : : sum : interest.

For example, to find the interest on £80 at 5 per cent—

100 : 5 : : 80 : 4.

To find the rate per cent, we say:—

As (sum − int.) : interest : : 100 : rate per cent. thus:—

As (84 − 4 =) 80 : 4 : : 100 : 5.

The Turkish Minister of Posts and Telegraphs has intimated that a new line of telegraphic communication with Greece has been opened by way of Tchesme and the island of Scio. The price of a single twenty-word dispatch from Constantinople to Syra has been fixed at the very stiff rate of 5s. 9d., an almost prohibitive tariff, one would think.

A Bill authorising a loan of £100,000, for the construction of a railway and telegraph from Geraldton to Northampton, and a line of telegraph from Newcastle to Champion Bay, has been passed by the Legislative Council of Western Australia.

APPLICATION OF ELECTRICITY TO THE REDUCTION AND REFINING OF METALS.

Amongst the specifications recently published by the Patent Office authorities are two, relating to inventions by Mr. Richard Werdermann, C.E., of great importance, as opening out a fresh application to electricity. The present purpose to which electricity lends its aid, is to the reduction of metals from their ores, and the refining and purifying of the reduced metals, without the ordinary chemical action of carbonaceous matter, the purifying and refining taking place at the same time and by the same process during the reduction from the ore. The ores, that is to say, oxides, sulphides, carbonates, or other combinations in which the metals exist in nature, are first crushed, and then heated in a suitable furnace or retort. After the whole charge is raised to a red heat two pieces of carbon or platinum, or some other suitable material which conducts electricity, are plunged in the crushed ore. These two pieces are connected by platinum or other suitable wires or ribbons with the two poles of a galvanic battery or magneto-electric machine. The electrical action and chemical decomposition which then take place may be seen from the following equations, which are given for the purpose of illustration, and are arranged in the order of their elimination.

		Negative Pole.	Positive Pole.
Oxide of Zinc	ZnO	Zn	O
Red oxide of copper	Cu_2O	$2Cu$	O
Plumbic oxide	PbO	Pb	O
Sesquioxide of manganese	Mn_2O_3	$2Mn$	$O+O+O$
Loadstone..	$FeOFe_2O_3$	$3Fe$	SO_3 As_2O_5 Ph_2O_5 SiO_2 SiO_2 CO_2
Hæmatite	Fe_2O_3	$2Fe$	
Brown hæmatite ..	$2Fe_2O_33H_2O$	$4Fe$	
Spathic iron	$FeCO_3$	Fe	
Sulphide of zinc (blende)	ZnS	Zn	S
Subsulphide of copper..	Cu_2S	Cu Cu	CuS
Sulphide of nickel ..	Ni2S	$2Ni$	SO_3 SO_3
Bisulphide of iron (pyrites)	FeS_2	Fe	$2SO_3$
Maganous carbonate	$MnCO_3$	Mn	CO_2+O
Carbonate of zinc (calamine)	$ZnCO_3$	Zn	CO_2+O

The reduction of iron ores may be effected either in the usual manner in the melting furnace with carbonaceous matter, or in a reverberatory furnace with some suitable flux only. The best ore for this purpose is the hæmatite, because it is a good conductor of electricity. As soon as the oxide begins to flow the reduction takes place, and all noxious elements are eliminated in the following order, viz. :—sulphur, arsenicum, phosphorus, titanium, silicon, carbon.

By regulating in a suitable manner the electromotive force and the intensity of the electric current, and stopping it at the proper moment, cast iron, wrought iron, or steel can be produced directly from the furnace without any intermediate operations. This puddling by means of an electric current will occupy from 10 to 15 minutes only, instead of several hours as in the ordinary puddling by hand labour or machinery, and consequently a great saving of time will be effected.

The entire liberation of the electro-negative elements is in some cases not effected immediately, but an intermediate transformation of the ore takes place. For instance, in treating the sub-sulphide of copper this ore does not conduct electricity at the ordinary temperature, but at 230° Fahrenheit it becomes a very good conductor; copper is then produced at the negative electrode or pole, and at the positive pole sulphide of copper is formed, which being a good conductor at a lower temperature is now entirely decomposed, and converted into metallic copper. A great difficulty in the reduction of plumbic oxide in the usual process consists in the formation of silicate of lead due to the presence of silicates mixed with the ore. This difficulty is entirely overcome by the application of the electrical current for the formation of the silicate of lead, which is readily fusible, is no obstacle, and all ores rich in silicates, which could not be treated till the present time, can now be employed for the extraction of lead.

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[*] "Many students are perplexed for a long time with such notions as that the *force* × time = velocity. They should remember that it means nothing more than this: if that which gives *a* feet of velocity in every second, be allowed to act for *b* seconds, then *ab* feet of velocity must result."—*De Morgan*.

Instead of treating the sulphides and carbonates and other more complicated combinations directly by the electrical current, such ores may first be converted into oxides by roasting them in the usual manner for some time in contact with atmospheric air or oxygen.

While the metal is being reduced all impurities and noxious elements mixed or combined with it are eliminated, so that finally the metal is collected perfectly purified and refined.

In purifying metals, the removal of the metals or metalloids which are to be eliminated is effected either in a melting furnace or in a crucible or converter or puddling furnace. Two pipes of fire-clay are dipped in the molten metal. Two hollow cylinders of carbon or platinum or other suitable matter are fixed inside the clay pipes at the end immersed in the molten mass. To the carbon or platinum cylinders are attached two platinum wires or ribbons, which run up inside the clay pipes and are connected directly or by means of copper wires to the two poles of a galvanic battery or magneto-electric machine. To prevent the development of heat in the battery or magneto-electric machine the connecting wires pass through a cooling apparatus. Instead of hollow cylinders of carbon or platinum, solid cylinders or sheets, or any other suitably shaped pieces of carbon or platinum or other suitable matter can be used; in the latter cases space must be left between the said pieces and the fire-clay envelope, to permit the eliminated metal or metalloids to be volatilised and to escape through the clay pipes, and to be collected in a suitable vessel in which they are converted either into the liquid or solid state or into salts, in bringing them in this *statu nascendi* in contact with any suitable matter to which they have great affinity.

Students' Column.

Electrical Measurement of Short Intervals of Time.

To have everything at hand when required appears to be one of the unattainable states of human existence. The telegraph engineer and the electrician are generally well convinced of the tendency of human affairs to a negative condition in this regard. Foresight provides against careless omission, but it would be a very commendable foresight that could provide against all possible requirements. A frequent necessity in physical measurements is the record of very small intervals of time, when there is not at hand such a complicate or expensive instrument as an electric chronograph; and we shall endeavour to describe such simple expedients as may be provided or obtained in any laboratory. We shall be indebted for the substance of our matter to Kohlrausch's "Physical Measurements,"* or rather to the excellent appendices by the translators, Messrs. Waller and Procter. The method that first presents itself is that invented by Pouillet, and consists in the observation of the deflection of a galvanometer; it is thus described in the work we quote:—

It is arranged that a circuit including a constant battery and a galvanometer shall be closed during the short time to be measured. If the period of closure be short compared to the time of oscillation of the needle, the amplitude of its first swing from its place of rest will be proportional to the time of contact. To determine the actual value in time of the deflection, M. Pouillet employed a rotating glass disc with a metal radial strip, which for a small part of its revolution made contact with a spring. M. Schneebeli (*Pogg. Ann.*, vol. cxliii., p. 239; and *Phil. Mag.*, vol. xliv., p. 477), who has successfully applied the method to measure the duration of collision of elastic bodies, used a metallic pendulum, carrying at its lower extremity a triple spring, which rubbed on a strip of steel fixed in the same vertical plane as the axis of rotation of the pendulum. A glass plate, applied horizontally to the steel, caused the spring to slide into it without shock. The duration, t, of contact was inversely proportional to the square root of the height of fall H of the pendulum, and b being the breadth of the strip—

$$t = \frac{b}{\sqrt{2Hg}}$$

If the resistance R, and electro-motive force t, of the circuit be known, and, consequently, the quantity passing through the galvanometer in the unit of time, the time, t, may be found by the following formula—

$$Q = \frac{Et}{R} = \frac{2nT}{\pi}\sin.\tfrac{1}{2}\theta;$$

where n is the constant of the galvanometer, T the time of a single vibration of its needle, and θ the angle of deflection.

The remaining methods are more or less approximate to the character of a chronograph, and include the following expedients.

The velocity of a rotating disc may be measured by smoking the rim of the disc, and lightly touching it with a tiny cone of india-rubber attached to one prong of a vibrating tuning-fork of a known number of vibrations per second. The lamp-black will be rubbed off in spots, and if n contacts correspond to m degrees of angular rotation of the disc, and the fork vibrates t times per second, the number of revolutions of the disc per second will be—

$$N = \frac{mt}{360n}$$

If the primary of an induction-coil be put in circuit by a connection which is broken at a given moment, a current will be produced at the instant of rupture in the secondary, which may register itself either by piercing a revolving paper disc with its spark, or similiarly, by marking a black-varnished metallic disc, or by making a brown dot on a paper prepared with potassic iodide and starch. A smaller spark is also produced by closure. This method has been applied to measure the velocity of a bullet, which successively divided wires placed across its course. If the velocity of the disc was not known, it might of course be determined by employment of a second coil, in which contacts were made and broken by a large tuning-fork, or other isochronous vibrator.

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* London: J. and A. Churchill. 1873.

The methods further described are those of MM. Lucas and Casin, and Wheatstone. These, however, relate to the measurement particularly of the time and transit of the electric spark itself; the student interested should refer to the work quoted, to Ganot's "Physics" (p. 627), and to Prof. Rood's experiments, TELEGRAPHIC JOURNAL, p. 132.

PAPERS FOR JUNIOR STUDENTS.

Induction (continued).

A STUDY of the preceding experiments (p. 302) will aid in the comprehension of the following principles deduced by Lenz, which are really the concise statement of what we have already learned.

Lenz's laws :—

I. The distance remaining the same, a continuous and constant current does not induce any current in an adjacent conductor.

II. A current at the moment of the circuit being closed, produces in an adjacent conductor an inverse current.

III. A current, at the moment it ceases, produces a direct induced current.

IV. A current that is removed, or whose intensity is diminished, gives rise to a direct induced current.

V. A current that is approached, or whose intensity is increased, gives rise to an inverse induced current.

VI. If the relative position of two conductors, A and B, be changed, of which A is traversed by a current, a current is induced in B, in such a direction, that by its electro-dynamic action on the current in A, it would have imparted to the conductors a motion of the contrary kind to that by which the inducing action was produced.

The last law will be more easily understood when it is known that two parallel wires, freely suspended, and traversed by currents in the same direction, will be attracted to each other, while if the currents are in opposite directions, the wires will be repelled.

Of the methods of obtaining induced currents, Prof. Edlund has shown II. and III. to be the most economical with regard to the work expended. For in bringing the inducing wire near the induced, as well as in removing it, work is performed; and, according to the theory of the conservation of energy, a quantity of heat proportional to this work must result. But when induced currents are obtained by the opening or closing of a circuit work is not lost, for the quantity of heat lost in the inducing current is evinced in the same quantity in the induced current.

Hitherto we have considered the inducing wire to be parallel to the induced wire in two straight parallel lines. But it is clear that the parallel direction still will be preserved if we wind the two wires each upon a bobbin, and place one bobbin inside the other—the bobbin of inducing wire inside the bobbin of the induced circuit. This done, we have constructed the apparatus known as an *induction coil.*

Presently we shall direct our students how to make an induction coil; now, however, we must learn the principles of the construction of the apparatus. Half the failures of amateurs to make their own instruments arise from a want of knowledge of *principle.* Who would think of setting a man who knew nothing of the subject to the designing and construction of a steam-engine? Yet a large number of persons imagine that by merely putting to a scientific paper the question "How can I make (say) an induction coil?" they will obtain a recipe, "mix together so much wire, so much wood, ebonite, and brass of certain shapes," and that by some process of nature a very effective and splendid instrument will result. How great a mistake! And how much time, trouble, and delay would be saved by a little study of *principle.*

But we shall find that the efficiency of our coil will be much greater if we wind the inducing wire upon a bobbin containing a core of soft-iron, that is if we construct a single, or bar electro-magnet of the inducing wire. Why this increase in the power of the induced current? Because we have raised to a higher magnetic condition the inducing wire.

Let us now remove this electro-magnet apparatus from the interior of the coil of the induced circuit, and substitute a permanent steel magnet; the effects are the same, and vary in strength with the magnetic strength of the steel magnet. This phenomenon is known as *magneto-electric induction.* It was illustrated by Faraday in the following experiment. He took a single hollow coil of wire of 200 to 300 yards' length, and connected the ends of this coil to the terminals of a galvanometer. The needle of the galvanometer was deflected, while the magnet was inserted into or withdrawn from the bobbin, the deflections being in contrary directions. When the magnet was unmoved, the needle of the galvanometer fell to zero.

This experiment may be varied. A bar of soft iron may be placed in the bobbin, and this bar magnetised by contact with a permanent magnet. Upon this principle most magneto-electro machines are constructed.

We are now in a position to comprehend the following laws relating to electro-magnetic and magneto-electric induction. The induced circuit will, in what follows, receive the general term of the *secondary circuit;* the inducing circuit, the *term of primary circuit.*

Notes and Queries.

LIGHT AND ELECTRICITY.

Some of our readers may like to try the following experiment:—Adjust a prism so as to get a well-defined solar spectrum, bring the violet rays to a focus on the eye of a fine cambric neeedle made so hard that it will scratch glass; this will magnetise the needle, proving that light will produce magnetism, by which a current of electricity may be induced in a small coil of very fine wire connected with the binding posts of a sensitive galvanometer; a slight movement of the galvanometer needle each time the magnetised cambric needle is caused to enter the coil, and a movement in the opposite direction when it is withdrawn, delicately prove the correlation of light to magnetism and electricity.

THE United States Signal Service has recently constructed a telegraph line to the summit of Pike's Peak, in Colorado, which is said to be the highest point reached by any line in the United States or perhaps in the world. The height is said to exceed 11,000 feet. Regular reports as to the weather are to be sent to Washington three times daily.

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The Meetings of this Society were resumed at the Hall of the Institute of Civil Engineers, Westminster, on Wednesday evening, the 12th inst.

The chair was taken by Mr. Cromwell Varley.

A paper "*On the Quadrant Electrometer*,"* by Mr. John Munro, was read by the secretary. The paper opened by stating that without proper means of measurement no science can prosper and become applied. As every electric phenomenon is primarily due to differences of electric potentials established among matter, an electrometer, or instrument for measuring differences of potentials, is a primary necessary to the advance of our knowledge of electricity, and our application of it to the arts. Since the last century various rudimentary electrometers have been contrived for experimental purposes, but these have been more or less crude and imperfect. The modern electrometer, besides answering the uses of scientific research, should be fitted for the commoner work, and should be adapted to measure alike the agency of a thunder-storm and the variations in the electromotive force of the most constant galvanic element. Its range and sensibility should therefore be great. The quadrant electrometer fulfils all these requirements to a hitherto unequalled extent, and for station employment far exceeds all others in utility. Difference of electric potential or electromotive force is thus defined by Sir William Thomson:—"The amount of work required to move a unit of electricity, against electric repulsion, from any one position to any other position, is equal to the excess of the electric potential with the second position above the electric potential with the first." Thus the difference of electric potential takes the form of mechanical work. The quadrant electrometer is, like all other highly-perfected contrivances, an instance of that process of evolution which goes on among mechanical as well as natural creations. Though so complete and complex in its present form, it had for its progenitor a large iron tank and a three-legged stool, but since that early day it has gone through several improving modifications. The paper proceeded to describe at length the various details of the instrument, and the method of using and adjusting it. These descriptions were illustrated by diagrams, and without such adjuncts would be quite unintelligible. Perhaps the best method hitherto tried of testing submarine cables by the electrometer has been successfully employed by Sir Wm. Thomson and Mr. Fleeming Jenkin in connection with the Great Western Telegraph Company's cables and the Brazilian Cable. This was fully described by Mr. Jenkin in a paper read to this Society on the 26th March. The use of the quadrant electrometer in research gives results of absolute measure. "The first step," says Sir William Thomson, "towards accurate electrometry in every case is to induce, from the scale-readings, numbers which shall be in simple proportion to the difference of the potentials to be determined. The next and last step is to assign the corresponding values in absolute electrostatic measure." These steps can be accomplished by means of this electrometer. Force is measured in grammes weight. The quadrant electrometer has also been long used as a self-recording measurer of atmospheric electricity. Its applications, however, are extensive in the whole range of electric science. In the meteorology of the future it seems destined to play an important part, and doubtless its aid will be invoked in other branches of human knowledge. Its importance as an instrument of electric research, and as an appliance of the telegraph engineer, is rapidly becoming recognised throughout Europe and America.

Mr. W. H. Preece said that he had listened with a great deal of interest to the paper just read. It was very difficult to follow from an oral description the details and architecture of an instrument such as the quadrant electrometer, and especially so when, unfortunately, the instrument itself was absent, although had they had the instrument before them they might not have been much more enlightened, for it was one which required very careful examination in all its parts. It was destined to become a most valuable auxiliary to the electrician, and he questioned very much whether any electrician's or telegraph engineer's apparatus could be complete until he possessed one of these appliances. Certainly no laboratory could be called a laboratory until one was on its shelves. The principles upon which the quadrant electrometer are constructed were, like the principles of all really beautiful instruments, excessively simple, and indications were given by a simple solution of one of the earliest problems taught in all education, the simple parallelogram of forces. The indicator or needle moving in the electric field was actuated in two directions, and it took up the resultant position; and by that means we had depicted upon a scale a spot of light which could be registered with the greatest ease, and which gave an absolute indication of the forces present. The instrument, as had well been remarked in the paper, was an example of that principle which was now gaining so much ground in philosophy in general—the princple of evolution. It was also an excellent example of Darwin's theory of natural selection and the survival of the fittest. All those who had experimented had, at different times, made use of electrometers and electroscopes of various kinds. The old gold leaf, and, in fact, the old straw, had gradually by this principle of natural selection been created into the quadrant electrometer. He did not think that any museum or any school could be complete until it had a kind of historical series of instruments showing the gradual change by which one form had passed into another. Speaking from experience he could say that young hands were far more easily taught to value all the alterations and details of an instrument by being shown the different stages through which it had passed in its career. Hence this society, when it became rich and possessed a museum, as he hoped it would, could not possibly do better than have a series of electrometers giving examples of this principle of evolution by showing all the stages through which the instrument had passed. There was one part of the instrument which was rather cursorily passed over in the description, but which really was one of its most beautiful points; that was the *replenisher*—the simple and easy means by which we were able every moment to keep the instrument up to its proper standard, and by which we were able at all times to obtain comparative and actual results. This replenisher was one of those many inventions of Mr. C. F. Varley. That gentleman being present, he would no doubt explain the replenisher in his usual clear way. The principle of accumulation upon which it was based was fully explained by him in the year 1860. That principle should be understood by everybody, because this was not the only instrument which was based upon it. Holtz's and other machines were based upon the same principle. The uses to which the quadrant electrometer had been put were mentioned in the paper. It had been for some time in use in Hooper's works. Its great merit was that, in testing with this machine, the experimenters could watch with the eye exactly what was going on. It was not as if they used a galvanometer, and had to dodge the cable to get the proper indications. When this electrometer was applied, the indications could be watched with the eye, just as one could watch the falling of the mercury in a thermometer, when it was placed in a vessel of cooling water. There were many practical purposes connected with telegraphy to which the instrument could be applied; and members of the society could not possibly do to science a greater service than to take indications at their different stations, for instance, upon the potentials of the earth. We were all troubled with earth currents. The earth current was a mystery to be unravelled, a problem to be solved. There were now telegraphists all over the world, and he was quite sure that if they would supply themselves with an electrometer of this kind, and take regular and well considered observations, we should then, by that means, be gradually accumulating those data which form the basis of every science. Another subject needing investigation was atmospheric electricity. We all fancied that we knew something about thunder and lightning and atmospheric storms, but really we did not, and our present views on those subjects were all conjecture. In that field we required to accumulate the same kind of facts as with regard to earth-currents, in order that we might be able to place atmospheric electricity on the true basis of a science. The quadrant electrometer itself had two or three practical uses to the student. One was that it gave him a clearer conception of that much abused term "potential" than any other machine which was placed in his hand. The paper had quoted Sir William Thomson's definition of "potential," and we knew the general definitions of the term; but to most of us these definitions were simply incomprehensible. But by playing with an electrometer, and conceiving the potential of electricity to be analogous to "temperature" as applied to heat, or to "pressure" as applied to moving liquids, we gradually acquired some knowledge of what potential was as a function of electricity. He must confess that he never fully and clearly learnt what the full meaning of the term potential was until he was able to play with an electrometer. There was another purpose for which this electrometer could be used. As they all knew, we were living in a stage of transition with regard to the general theories and opinions about electricity. No two men were agreed as to what electricity was. Some said it was a fluid; some said it was the ether; some said it was a force. Those differences of opinion were a simple proof that we had not yet arrived at the true basis of electricity. It was found that in describing such a simple phenomenon as that which was observed in the galvanic battery, telegraphists and electricians were still divided into two great schools. One school ascribed the birth of voltaic electricity to chemical action, and the other described it to contact—the contact of two dissimilar metals. For the last half-century the scientific world had been divided on this subject. Continental philosophers generally said that the origin of electricity was to be found in contact. English electricians, following in the path of their tried philosopher and friend, Faraday, ascribed it to chemical action. The tendency of the philosophy of the present day was to draw a line between these two views—in fact, to make a compromise between the contact theory and the chemical theory. Helmholtz in Germany, and Sir William Thomson in England, had started the theory that the first kick which set the ball rolling was contact, and that the motion was maintained by chemical action; in other words, that the first action which took place in the battery was not the chemical affinity between the elements of the battery and the plates, but the contact of dissimilar bodies. The electrometer enabled us to perform, with the greatest ease and simplicity, an experiment which showed at once that there was such a thing as contact electricity. De la Rive, in his elaborate treatise, had devoted a very large chapter to show that there was no such thing as contact electricity. He ascribed the electricity to the moisture of the fingers that held the plates, or to the moisture of the atmosphere, or to some cause which might produce chemical action. By means of this electrometer we could see, upon simply placing together two dry plates, one of copper, and one of zinc, and then rupturing the connection between the two, that there was a very strong evidence of electricity; and the usual explanation, that this was due to the moisture of the air or finger, was exploded by the moistening of the finger during the contact, in which case there was no motion at all on the electrometer. This proved that there was such a thing as contact electricity, and that that was the real and true basis of voltaic electricity. In future treatises it would be found that the theory which was gaining ground was, that the electric current was produced in the first instance by contact, or, in other words, that contact was, as he had previously said, the kick which set the ball rolling. In conclusion, he would again express a hope that the members of the society would supply themselves with the quadrant galvanometer, and make such observations as would place on the true basis of science facts connected with earth currents and atmospheric electricity.

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* The full abstract of the paper by Mr. Munro upon the "Quadrant Electrometer" will appear in our next, illustrated.

Mr. Jamieson stated that he had used the electrometer for the last ten months in testing the Platino-Brazilian cable for Sir William Thomson and Mr. Jenkin at the works of Mr. Siemens, and then explained the mode of operating.

The Chairman said that the paper was one of those which deserved from this society great consideration, and the author of the paper deserved their warmest thanks for giving them a written description of an instrument which was coming more and more into use every day. When the testing of a cable by the diminution of the charge left in it was first proposed, it was almost universally ridiculed, as all good things are. That time dated back to about the year 1848; and, like the electrometer, that method had gone through a series of developments, until it had at last been knocked into such a shape that it was now incomparably the best method of getting at the true electrical condition of an insulated conductor. It was very important indeed to the members of the society and all telegraphers that accurate descriptions of such apparatus, and the mode of using them, should be clearly stoted in such a manner as to be easily intelligible to those who wished to make use of the apparatus. One of the great merits of testing the insulation of a cable by an electrometer is that it did not interfere at all with the charge in the cable. The cable being charged, the electrometer simply looked at it. Just as a telescope used for reading off from a distance the time indicated upon a clock-dial in no way interfered with the working of the clock, but simply regarded what was going on, so the electrometer really did not touch the cable, and consequently the cable was entirely free from all disturbances such as those due to the battery potential, or battery resistances, or resistances of the galvanometer, or imperfection of insulation in the galvanometer. The electrometer method of testing was incomparably better than any other on account of this freedom from disturbances. He was not aware whether the electrometer had yet been so far perfected as to be available on board a ship in a storm; but the day was not far distant when that difficulty would be overcome, if it had not been overcome at present. The method which Mr. Jamieson had just described, and which was being adopted for the Brazilian cable, was very clearly set before the society this year by Mr. Fleeming Jenkin. He (the chairman) took a little pride in being the first to propose that method of testing. They would find it published in a patent of his in the year 1861. The arrangement he then proposed was, however, nothing like so complete as

Jenkin's method. From the time occupied in running down from any one potential to any other, the insulation of the cable was easily deducible. One objection to this early method of working was that he used so many cells of the battery, not having at that time the potential divider of Sir William Thomson. Another objection was that without a mirror the instrument was not sufficiently sensitive unless a battery of from 500 to 1000 cells was employed, and this, to say the least, was inconvenient. But still there was the germ of the present method of testing, which has been perfected by Sir William Thomson and Mr. Jenkin in connection with the Brazilian cable. Mr. Preece had asked for further information as to the replenisher. The author of the paper had stated that the original quadrant electrometer consisted of a large iron tank and three-legged stool. In like manner the replenisher arose out of tin saucepans and cake-tins. The first experiments upon it resulted from a severe fit of indigestion. Being very unwell, he (the chairman) went out for a walk, and proposed to himself a subject to divert his thoughts from his own suffering. He tried to find out the source of electricity in a frictional machine. He hit upon the replenisher, returned home in a hurry, tried the device, and at last succeeded. He had gone on working at the contrivance for some time without seeing any result, and he began to despair of success, but at last the electrometer discharged itself. He ought to state that he constructed several machines upon this plan; and before Sir William Thomson brought his electrometer to perfection he (the chairman) had laid down (as would be found in a patent of his in 1860) the law governing the rate of multiplication of the charge of these machines, and showed how an unsensitive electrometer could be made available for small charges by this mode of augmentation. With reference to the reflecting electrometer, it would be found, in dealing with minute variations of potential such as the fraction of a cell, that the surface of the metal itself would at times give some inconvenience through producing charges on its own account. For instance, if a piece of metal became oxidised, having previously been bright, its potential immediately changed. He had hence found it convenient to have all the parts of the electrometer well electro-gilt. Only a small sum of money was required for this process, and corrosion was entirely got rid of. There was always clean pure gold presented to clean pure gold, and the instrument was greatly improved by the gilding. He would strongly recommend all persons who were about to invest in a reflecting electrometer to go to the small extra expense of having all the parts gilt. There was one more point to which he would refer, though it was somewhat wide of the paper. He was very glad that Mr. Preece had alluded to it. It was the question as to the source of electricity. Was it contact, or was it chemical action? The position which he took up in that matter, after careful consideration, was that contact alone would not give us electricity, and chemical action alone would not give s electricity, but there must be both.

Correspondence.

ACTION OF AN ELECTRO-MAGNETIC COIL ON A MAGNET.

To the Editor of the Telegraphic Journal.

Sir,—In your issue of May 15, in the column under the head of "*Action of an Electro-Magnetic Coil on a Magnet*," it is stated that "a magnet (needle) in the axis of a circular current is attracted to or repelled from the centre with a force proportional to the superficial content of the circle," or, in other words, the force is proportional to the square of the radius.

Now, it is well known (see "Electricity and Magnetism," by Professor Fleeming Jenkin, page 142, section 8), that the strength of the magnetic field produced by a circular current of strength (C) and of radius (k) at a point in the axis, at a distance (x) from the plane of the circle is equal to—

$$\frac{\pi C k^2}{(k^2+x^2)^{\frac{3}{2}}}$$

and is, therefore, *not* proportional to the square of the radius.—I am, &c.,

W. E. Ayrton.

Prof. Nat. Phil., The Imperial College of Engineering,
Tokei, and Hon. Sec. for Japan of the
Society of Telegraph Engineers.

METHOD OF DETERMINING THE RESISTANCE OF OLD TELEGRAPH WIRES.

To the Editor of the Telegraphic Journal.

Sir,—Mr. W. E. Ayrton assures us, in your journal of November 1, that the method given by Mr. Brooks, in his article, "*Method of Determining the Actual Resistance of Old Telegraph Line Wires*," published in the *Telegrapher* of April 5, 1873, and reproduced in your journal of May 15, is not *new*. I can give on this point an explanation of some importance, I believe.

In the French journal, *Les Annales Telegraphiques*, July—August, 1865, I have published an article, "*Methode pour Mesurer la Resistance Absolue d'Anciens fils Telegraphiques*." The above-mentioned article of Mr. Brooks is not more than a simple reproduction of mine in the *Annales*, as any one can remark, Mr. Brooks using *from the beginning to the end of his article the same words in English as I did in French language*.—I am, &c.,

J. W. Hagers.

Inspecteur of the Government-Telegraphs in the
Netherlands, Station Rotterdam.

November 6, 1873.

[It will be better to state the assumption upon which the translations and abstracts of notices of "Electrical Science in Foreign Journals" are given—that is, we do not question, and cannot therefore be answerable for, the accuracy or authorship of the remarks in the original.—Ed. T. J. and E. R.]

A Just Tribute to American Telegraph Engineering.—W. H. Preece, Esq., Divisional Engineer of the English Post-Office Telegraphs, and a prominent member of the Institute of Civil Engineers, and also of the newer, but already quite distinguished, Society of Telegraph Engineers, has been publishing, in the Telegraphic Journal, a series of highly interesting articles on Duplex Telegraphy, beginning at the very inception of the idea, and coming down through all the various attempts by Gintl, Siemens, Frischen, and others, to the successful solution of the problem by Stearns, to whom, in the last number of the Journal, he incidentally pays the following tribute:—"Duplex telegraphy was thoroughly exhausted in 1856, and with our then means it proved a failure. It has now, thanks to Mr. Stearns, and to our improved means, proved a success; not, however, so much by the reproduction of exploded plans, as by the introduction of methods which are as novel as they are ingenious, and which I shall shortly explain." Words of appreciation like these, coming from so distinguished a source, are very gratifying to us as fellow-countrymen of Mr. Stearns, and must be doubly so to the distinguished inventor himself, to whom they prove that the scientific men of England, who have done so much to advance the science of telegraphy, are not unwilling to accord full credit to their American cousins for what they have accomplished in the same field.—*Journal of the Telegraph.*

Gutta-Percha.—This year the value of gutta-percha imported was £315,454; last year, in nine months, £296,431.

Electrical Science in Foreign Journals.

The Telegrapher. Vol. ix., No. 377.

Electricity at the Cincinnati Industrial Exposition.—The fourth Cincinnati Industrial Exposition, under the joint management of a Board of Commissioners from the Chamber of Commerce, the Board of Trade, and the Ohio Mechanics' Institute, was opened to the public on the 3rd of September. The unusual number and attractiveness of the premiums offered by the managers for electrical and telegraphic apparatus has brought together the most extensive exhibition of this kind ever seen in the United States. This department appears to be especially attractive to the eye of the greater portion of the visitors, owing to the well-known fact that the average citizen from the unpaved districts, who forms a large part of the crowd at exhibitions of this kind, is always deeply interested in the workings of electricity. He gazes at the mysterious movements of the polished mechanism with wonder and awe depicted on his countenance. He firmly believes in his own heart that electricity is the cause of everything that happens in this world that is otherwise unexplainable, from earthquakes and steam-boiler explosions down to spirit rappings and clairvoyance. Messrs. Gamewell and Co. have on exhibition what is known as the Automatic Fire Alarm Telegraph. The most novel, and one of the most valuable parts of the apparatus, however, is what is very properly termed the "non-interference" feature. In the exhibition the apparatus—signal boxes, bell and gong strikers—are divided between two separate and distinct circuits. In actual operation in cities the number of circuits may be increased indefinitely—no matter what the number may be, an alarm from any one signal box is automatically repeated over all the circuits through an automatic mechanical repeater, operated by weight power, which is controlled by the operation of an electro-magnetic escapement. The non-interference feature operates in the following manner: An alarm having been started by the pulling of the hook in one of the signal boxes, every other box on the same circuit is "cut out" through a peculiar device in each box, and the boxes on all the other circuits are "cut out" by the operation of the repeater. Pull as many boxes as you please, and if one starts a second or two in advance of the others that one has the right of way, and no other alarm can be sent in until that is finished. The repeater referred to is from the manufactory of Moses G. Crane, Boston, Mass. All the apparatus is handsomely finished and nickel-plated, presenting a marked contrast to the crude looking and roughly made instruments of the original fire alarm, which Mr. Farmer put up in Boston nearly twenty years ago, but which contained the leading features of the beautiful and complete system of to-day, though so changed in form as scarcely to be recognisable by the unprofessional eye. L. G. Tillotson and Co. of New York, have a large show-case filled with samples of different kinds of telegraphic and electrical goods. A small but important point about the relays is worthy of notice. The armatures are insulated from the supporting lever, so as to prevent the possibility of a cross between the main and local circuits, in case the armature touches the poles—a feature which every experienced telegrapher will at once see the value of. The Telegraph Supply and Manufacturing Company, of Cleveland, Ohio, also have a collection of apparatus on exhibition, consisting of the usual variety of keys, relays, sounders, registers, &c. The principal novelty is a key provided with an adjustable supplementary spring circuit closing point, by means of which the dots of the sending operator are lengthened by a device similar to that employed in repeaters. This feature should be a valuable one in many instances. The relays and sounders are constructed with adjustable pole pieces—an invention of the late Geo. B. Hicks—by which the action of the relay can be regulated to suit the varying conditions under which it is required to work, and a much improved action is said to result therefrom. This company also exhibits a pair of Wheatstone magneto dial instruments for private lines, but whether manufactured by themselves or imported we were unable to learn. Mr. E. C. Armstrong, of Cincinnati, shows several different kinds of instruments for private telegraphy. A pair of Hamblet's magneto dial instruments, from E. Howard and Co., of Boston, occupy a conspicuous position. A magneto dial printer, from G. L. Anders and Co., of Boston, is a telegraphic novelty, appearing to possess qualities which will, in all probability, win for it an extensive popularity. Requiring no battery, easily adjusted, simple and rapid in operation, it bids fair to become a general favourite for private lines. The Selden-Burrell Printer, which took the premium in its class last year, is again on exhibition at Mr. Armstrong's stand, as is also a dial apparatus very similar to that of Chester, also from Mr. Burrell. H. D. Rogers and Co., agents of the Gold and Stock Telegraph Company of New York, exhibit a pair of Gray's Type Printers for private lines, and also a pair of Edison's Universal Printers, intended for the same work. Four of the well known stock printing instruments of the Gold and Stock Company are shown in actual operation, together with the motor-transmitter employed to operate them. The whole affair excites great interest among the visitors, and the machines are always surrounded by a dense crowd of spectators. Mr. Rogers also shows his little key and dial instrument, which was referred to in our last year's report of the Exposition. Dr. Nicholson, of Mount Washington, Ohio, shows a curiosity in telegraphy, on which he has been labouring for a number of years, and which created some discussion at one time in the telegraphic journals. In effect it is a sort of a duplex transmitter, except that the two communications go in the same direction at once, instead of opposite. The effect produced is the same as that of the system of Stark, of Vienna, described in Sabine's work on the telegraph, but the principle of action is unlike Stark's. By the use of Dr. Nicholson's peculiar alphabet, one operator may send communications by working both keys, at the rate of sixty words per minute, although it is not easy to see the practical advantage of this result, inasmuch as few operators can copy over half this speed for any length of time, and if copyists are to be employed, we might much better use the automatic system at once, and transmit 600 words per minute instead of sixty. In no department of telegraphy has more progress been made within a few years than in the matter of batteries. The managers of the Exposition wisely offered a premium for the best battery, for which there are two entries, both of which are new and very meritorious inventions. The Eagles Metallic Battery is exhibited by F. L. Pope and Co., of New York. This is a metallic battery, the elements being lead and zinc, and the exciting agent sulphate of copper. It is valuable in consequence of its low resistance, giving great power in a small space, and its constancy, which is especially noticeable when it is used in a circuit open a considerable portion of the time. The twelve cups shown in the Exposition are employed in working an extensive system of railroad signals, and the somewhat difficult requirements of this service are fulfilled by it in the most admirable manner. It is especially well adapted for a telegraphic local. The Lockwood Battery is exhibited by the Lockwood Battery Company of New York, and is also used in operating Gamewell and Co.'s fire alarm apparatus in the Exposition. This remarkable invention attracts a great deal of notice from the telegraphic visitors. The perfectly sharp line of demarcation between the blue sulphate of copper solution and the colourless zinc solution, and the clearness and transparency of the latter, renders this battery a beautiful and noticeable object. It is largely used by the Fire Alarm and American District Companies, with the most satisfactory results. Professor Henry Morton, of the Stevens Institute of Technology, says that this battery "occupies the first place among current producers for closed circuits;" a position to which its remarkable constancy, economy, and cleanliness would certainly seem to entitle it. The silver medal offered for the best adaptation of the telegraph to domestic purposes, has induced the American District Telegraph Company to exhibit the working of their system for furnishing messengers and police service, and protection from fire and burglars. Edwin Holmes, of New York, exhibits his system of burglar alarm telegraphs. Dr. L. Bradley, of Jersey City, has a set of his electrical measuring apparatus. The Electric Railroad Signal Company, of 38, Vesey-street, New York, show a full sized set of Pope's Patent Electric Semaphores in practical operation. By means of this simple and effective invention a signal of any size may be operated at any distance, and all its indications repeated back to the operator on the same wire. Several of these signals are in use on the main line and branches of the Pennsylvania railroad. Marks and Natcher have an electric bell signal for railroads. The Cincinnati Electric Gas Lightning Company show their apparatus for lighting gas by electricity, consisting of a small hard rubber electrophorus, attached to the bracket. By giving this a slight turn a spark lights the gas. A portable electric torch is arranged upon the same principle, and is employed in lightning chandeliers, etc.. The Western Union Telegraph Company have arranged a very tasteful and neat little office for the transaction of commercial business, under the music pavilion, in the centre of the main hall. The whole number of gold, silver, and bronze medals offered for premiums in the telegraphic and electrical department is twenty-two, and there is more or less competition for all except one or two of them. The only objectionable feature about the arrangements at Cincinnati is in the classification of electrical with optical and philosophical apparatus. The former is becoming one of the great industries of the country, and certainly deserves to be put into a class by itself. The judges, if they are electricians, are pretty sure to know nothing about spectacles or photographic cameras, and the same is even more true in the opposite case, which leaves an opportunity for great injustice to be done. If the electrical apparatus should be classed by itself, under the system which judges are now appointed, the exhibitors would be almost certain of two out of three of them being competent and unprejudiced experts, and their awards would carry a weight which would stimulate every manufacturer and inventor in the country to a vigorous competition for them.

Winding Magnets to a Given Resistance.—Mr. Brooks, of Philadelphia, made a careful series of experiments upon the winding of magnets, the results of which were published in the *Scientific American* two or three years since, and also in *The Telegrapher* of March 11, 1871. His relay had two spools, each two inches long and one and a half inches external diameter, with half inch cores, so that the thickness of the layer of wire was one half inch. By winding it successively with different sizes of silk-covered wire, he obtained the results given in the Table (see top of next column.) The sizes of wire given are Birmingham gauge. Of course, this table cannot, from the nature of things, be strictly accurate. The sizes of wires are never absolutely uniform, nor is the specific conductivity of the copper of which the wire is composed. But, in practice, the figures wil prove a sufficiently close approximation. The diameter of spool and core given, is more commonly employed in telegraphy than any other. Of course, if the length of the spool is increased, the number of convolutions and also the resistance will be augmented in exactly the same proportion.

Relays. Size of wire.	Number of Convolutions.	Resistance. Siemens units.	Relays. Size of wire.	Number of Convolutions.	Resistance. Siemens units.
No. 20	1616	4·20	No. 28	6,536	87·0
" 21	1904	5·92	" 29	8,016	135·5
" 22	2256	8·32	" 30	9,496	184·2
" 23	2816	16·60	" 31	10,784	280·1
" 24	2376	25·60	" 32	12,080	376·0
" 25	4136	39·80	" 33	12,568	416·0
" 26	5088	46·20	" 34	13,064	504·0
" 27	5828	67·50	" 35	13,600	560·0

Der Naturforscher. September, 1873.

On the Electrical Torpedo (Eel).—By M. Franz Boll.

On the Influence of Forests on Ozone Currents.—By M. Ebermayer.—In examining the influence of forests on ozone-currents of the air, the author finds there is more ozone in and near forests than in the open, among the denser branches less than in the open close to the forest, and in the tops of trees less than in the lower parts.

Les Mondes. Vol. xxxii., No. 9.

Electric Lighting.—A description of the apparatus employed to ignite the gas at meetings of the National Assembly, at Paris. The electric apparatus consists of (1), a battery of four large Leclanché couples equal in total to about three Bunsen elements; (2), an induction-coil, with a Foucault mercury break; (3), a commutator between battery and coil; (4), another or distributing commutator between coil and gas-jets; (5), 1400 metres of connecting wire running to each group of 252 jets. The immense hall can be lighted in 20 seconds.

Experimental Studies on Electric Resistance of Metals.—By Dr. Benoit.—Given in an earlier number of this journal.

New Anode for Galvanoplastic.—By M. C. Guerin.—A promise of the description of a successful method of working in copper.

Bulletin de l'Académie Royal de Belgique. No. 8, 1873.

A Recording Meteorograph.—By M. Van Rysselberghe.—The advantage is that the readings of several different instruments can be recorded by means of a single steel graver, making traces on a varnished copper sheet. The sheet is fixed on a vertical cylinder, which rotates at equal intervals (*e.g.*, every ten minutes); an electric circuit, of which the instrument to be observed forms part, is closed by the movement of the cylinder; this liberates the graver, which then gives a tracing proportional, in length, to the indication of the instrument. At each revolution the graver descends a little; thus a series of equidistant lines are obtained, the extremities of which form the curve of observations. The copper sheet is afterwards dipped in an acid, and thus made ready for engraving.

Sitzungsberichte der Kœnigl. Bœhmischen Gesellschaft der Wissenschaften in Prag. June, 1872.

A Mathematical Investigation of the Distance-Action of Solenoids on Material Plane Surfaces.—By Dr. Weyr.

Dub's Law of Dependence of Magnetic Moment on the Dimensions of a Magnetic Bar.—A note by M. Domalip, furnishing experimental proof.

City and Commercial Notes.

THE Brazilian Submarine Telegraph Company have announced a postponment of the opening of the Lisbon and Madeira section of their line. The cable was laid between Lisbon and Madeira on the 19th of September, but the section proved imperfect owing to the development of a fault. On the 26th ult. the cable, in an attempt to recover it, was broken, and, owing to the subsequent continual bad weather and loss of grapnel rope, the contractors have for the present ceased further operations, and the company have agreed to a proposal of the contractors to defer sending the second section to sea until the spring of 1874; these arrangement will enable the Board to postpone the payment of the final call until the 31st of March, 1874. It is anticipated that both the second and third sections will leave in April, when the repair of the first section will also be proceeded with, in order that the whole line may be in working order by the summer of next year.

The *Echo*, of Nov. 3, has the following account of a new aid given by telegraphy to the press:—"We give our readers an *actual* report of the business done upon the Stock Exchange, by special wires which connect this Office with that institution. An instrument, which is the special property of the Exchange Telegraph Company, prints on a continuous paper tape, in distinct letters and figures, the transactions of the Money Market, and the paper tape on which these facts and figures are recorded is in our printers' hands in less than one minute after the bargain is named on the Stock Exchange. We may add that the galvanic charge required for this work is so far in excess of the requirements of Ordinary Telegraphy that it was found upon experiment that such wires as connect this Office with other centres of information would be destroyed by the work."

The Brazil and River Plate Telegraph Company. It is announced in the *Buenos Ayres Standard* that the great event in Uruguay was the opening (which took place on the 12th September last) of the land lines of the Brazil and River Plate Telegraph Company (Compania Telegraphica Platino Brazileira), represented in London by Messrs. Grant Brothers and Co., of Lombard-street. The lines were working most successfully, the first days messages having amounted to the satisfactory number of 120, which considerably exceeded the expectations of the Company.

The receipts for the month of October, 1873, of the Submarine Telegraph Company, amounted to £9419 17s. 5d.; the receipts for the corresponding month of last year were £9,490 13s. 7d.

The Eastern Telegraph Company have notified that their cable between Vigo and Lisbon has been repaired, thus re-establishing direct submarine communication with Lisbon, Gibraltar, Malta, Egypt, and India.

The traffic receipts of the Eastern Telegraph Company, Limited, for the month of October amounted to £29,229, against £31,405 in the corresponding period of 1872.

The Eastern Extension, &c., Telegraph Company's traffic receipts for the month of October amounted to £17,586.

The total traffic receipts of the Great Northern Telegraph Company have been, during October, 1873, 356,940 francs; and in the corresponding period of 1872, 243,553 francs. On the European Lines, in 1873, 167,288 francs: in 1872, 154,764 francs. On the China and Japan Lines, in 1873, 189,652 francs; in 1872, 88,789 francs.

According to the Report of the Directors of the West India and Panama Telegraph Company (Limited), for the year ending Sept. 29, 1873, to be presented at the fifth ordinary general meeting of shareholders on the 17th inst., the receipts for the year amount to £26,185 10s. 8d., and the expenses, including interest, to £25,699 18s. 1d., leaving a balance of £485 12s. 7d. The directors attribute this unsatisfactory result to the condition of many of the cables, as reported to the shareholders at the last general meeting. Both the International Ocean Telegraph Company's Cables from Key West to Havana were interrupted from the 15th of June, 1872, to 1st May, 1873. They have been repaired or replaced. The Jamaica-Porto Rico Cable, on which so much depends, ceased working on the 26th January, and was not repaired until the 7th August. The Dominica-Martinique failed on the 20th January, and, having worked intermittingly till Sept. 2nd, has since been dumb. The Trinidad-Demerara Cable was interrupted from February 20th to September 2nd. The Jamaica-Porto Rico and the Trinidad-Demerara Cables were repaired by the Telegraph Construction and Maintenance Company, under arrangements approved at the extraordinary general meeting on the 17th March last. The subsidies received during the year amount only to £5401 11s. 9d. The full amount payable by the various Governments, of whose offers of subsidy the company has as yet been able to avail itself, viz., £16,800, would have been received but for the interruptions mentioned above, some of the Governments having withheld their payments during these interruptions. Sir Samuel Canning has submitted the following report, dated October 30th, viz.: "*Jamaica and Porto Rico Section.* Since the repairs on this section have been completed, I have received from Mr. Theophilus Smith a report of its electrical state, and regret to say that it is in a most unsatisfactory condition. Mr. Smith tested the cable to Holland Bay, from the end, on board the repairing ship, when the fault was cut out in the Mona Passage, and he found the insulation exceedingly defective, and when the repairs were completed, and the whole line tested from Porto Rico to Jamaica, the results showed the cable to be electrically in a very bad condition, so much so that, in its present state, it may be expected to break down at any moment. Under the above circumstances, and having given the subject most careful attention, I beg to submit to you a proposition which, I am of opinion, requires your earnest and immediate consideration. I would recommend that the cable now being manufactured by the Telegraph Construction and Maintenance Company for the Panama Route be now laid between Jamaica and Porto Rico or St. Thomas, to duplicate the present line which is in such a dangerous condition. This line should be laid to the south of the Island of Porto Rico; the length of cable now being manufactured would reach as far as Ponce, in Porto Rico, which should be considered a temporary landing place, as my advice would be to extend this line to St. Thomas, so as to have a direct line from Jamaica to St. Thomas." The directors have decided to lay the new cable, now made, from Jamaica to Porto Rico, instead of to Colon as at first intended. They have recently been informed of an interruption to the Cuba Submarine Telegraph Company's Cable between Batabano and Santiago de Cuba, and that steps have been taken for its repair. The directors who retire at this time are—Mr. C. W. Earle, Mr. Thos. Hughes, M.P., and Mr. J. A. Tinne; being eligible, they offer themselves for re-election. Mr. Cyrus W. Field has joined the board as representative of the International Ocean Telegraph Company.

The charges for telegraphing to India by the Indo-European lines *via* Teheran will be greatly reduced from Saturday next.

The last list of the Indo-European Telegraph Company shows an average time taken in transit between London and Calcutta of 1 hour 19 minutes; Bombay, of 1 hour 25 minutes; other stations in India, of 1 hour 59 minutes.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Nov. 14.
Stock	Anglo-American (Limited)	100	84½—85½
10	Brazilian Submarine..	9	2¾—2¼ dis.
10	Cuba	All	8—8½
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	14	7—5 dis.
10	Eastern (Limited)	All	8⅜—8⅝
10	Ditto New	All	—
10	Eastern Extn. Australia and China	All	8¼—8½
10	Great Northern	All	8¾—9¼
25	Indo-European	All	15—16
10	Mediterranean Extension (Limited)	All	4¼—4¾
10	Do., 8 per cent Pref...	All	11—12
10	Panama and South Pacific	2½	3½—2½ dis.
8	Reuter's..	All	10—11
Stock	Submarine	100	240—250
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	4⅝—4⅞
10	Do., 10 per cent Pref.	All	8½—9
20	Western and Brazilian (Limited) ..	All	12—13
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	90—92¾
10	Hooper's Telegraph Works	All	11¼—11¾
50	India-Rubber and Gutta Percha ..	All	27—29
Cent.	Submarine Cables Trust	100	107—110
12	Telegraph Construction	All	29½—30
100	Ditto Ditto 7 per cent Bonds	All	102—104

The Annual Meeting of the Western Union Telegraph Company was held at the Company's office, 145, Broadway, New York, October 8th, on which occasion a large proportion of the capital was represented. From the report presented by Hon. William Orton, President of the Company we find that the capital stock of the Company at the close of business, on June 30th, 1873, was 41,073,410 dols., of which there was outstanding 33,778,175 dols., and owned by the Company, 7,295,235 dols. The debt of the Company on that day was 6,038,410 dols., of which there was due Oct. 1, 1873, for American Telegraph Company bonds, 89,500 dols.; in November, 1875, for Western Union currency bonds, 4,448,900 dols.; in 1902, for Western Union gold bonds, 1,500,000 dols. The gross receipts of the Company for the year, from all sources, were 9,333,018.51 dols.; the gross expenses, 6,575,055.82 dols.; and the net earnings, 2,757,962.69 dols. On the 1st day of July, 1872, the Company operated 62,032 miles of line, 137,190 miles of wire, and 5,237 offices. At the close of the year ending June 30th, 1873, it operated 65,757 miles of line, 154,471 miles of wire, and 5740 offices. The increase during the year has been 3,725 miles of line, or 6 per cent.; 17,281 miles of wire, or 12·5 per cent., and 503 offices, or 9·5 per cent. For the construction, re-construction, and repair of lines, there were used 141,498 poles, 261,715 cross arms, 1,033,270 insulators, and 1,100,265 pins and brackets. There were in the employ of the Company, on the 30th of June, 1873, 9190 persons. Of these, four were general superintents of divisions, 29 superintendents of districts, 5,514 managers and operators, 1830 messengers, 661 clerks, 589 foremen of construction and repairmen, 116 mechanics in factories, 84 battery-men, and 275 miscellaneous. There were in use on the lines of the Company at that date 6,350 sets of instruments for reading by sound, 1878 recording instruments, 8601 relay magnets, 8905 transmitting keys, 227 repeaters, 15 printing instruments, 94 sets of duplex instruments, 2662 switchboards, 3472 cut offs, 3029 lightning arrestors, 21,777 cups of main battery, and 11,717 cups of local battery. The cost of new instruments and apparatus supplied during the year was 140,877.52 dols., and of battery material and supplies, 146,793.68 dols. The number of messages transmitted during the year ending June 30th, 1872, was 12,444,499, and for the year ending June 30th, 1873, 14,456,832, being an increase of 2,012,333, or 16·1 per cent. This includes press reports reduced to messages on the basis of 30 words to each message. The average toll collected upon each message for the last year was 61 cents, the average cost of transmission 42 cents, and the average profit per message 19 cents. The annual cost of maintenance of the plant for the past five years has been as follows: Cost of maintenance per mile of line—1869, 14·50 dols.; 1870, 15·30 dols.; 1871, 15 dols.; 1872, 16·59 dols.; 1873, 20·37 dols. Cost of maintenance per mile of wire—1869, 7·23 dols.; 1870, 7·72 dols.; 1871, 7·23 dols.; 1872, 7·67 dols.; 1873, 8·66 dols. The cost of reconstruction was heavier than usual in the Eastern States, on account of the large number of poles which required renewal during the past year.

Telegraphic Extensions and Construction.—The present year has been an exceptional one as regards telegraphic extensions and the inauguration of telegraph enterprises. There seems to have been a general pause and partial suspension of telegraphic operations, for which, however, there are many good reasons, and which will probably be found ultimately advantageous. There has been, however, a good deal of construction and reconstruction done by the Western Union Company—mainly, however, to increase facilities on important routes, and to keep up the status of its various lines. Owning and operating, as this company does, so extensive a telegraph system, there is necessarily a large amount of reconstruction and repairs to be done every season.

The Atlantic and Pacific Company has extended its wires into the oil region of Pennsylvania; but, with this exception, has done little in the way of extension. There has been, besides, the usual amount of repairs and some reconstruction of its lines going on, but nothing of special note.

The Southern and Atlantic Company is pushing on its wires towards New Orleans, and, so far as we know, this is the only company which is engaged in developing new lines of any considerable extent. Various obstacles have from time to time delayed and retarded the progress of its lines; but they are making substantial headway, and it will not be long now before it reaches New Orleans, and affords to the Southern metropolis what it very much needs—a reliable competing line, to divide the business with the Western Union Company, which at present has a practical monopoly of it.

We are informed that the Southern and Atlantic Company has been very favourably received in the territory through which its lines are operated, and that there is a general disposition to favour and patronise it as much as possible. A more energetic management has been recently established, and the prospects of this company appear to be very good. If a competing Atlantic cable telegraph line ever should be constructed to this country, it would be essential that it should have an adequate and comprehensive telegraph system to connect with here. The lack of any suitable connecting telegraph system in this country had an important and, we think, a decisive influence in bringing about the arrangement between the French Cable Company and the Anglo-American, which has now resulted in their consolidation into a single company, and established a monopoly of the telegraph business between this continent and Europe, which it will be found costly and difficult, if not absolutely impossible to overcome.—*The Telegrapher.*

To Correspondents.

A Student.—Noad's "Student's Text-Book of Electricity." Any respectable bookseller will procure it.

Magnet.—M. Waltenhofen found that the magnetic moment of the unit of weight of iron attains a certain limit independent of the form and dimensions of the electro-magnet. Permanent magnetism with steel bars rarely exceeds 400 units per milligramme, iron temporarily attains to a limit five times greater than this.

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